POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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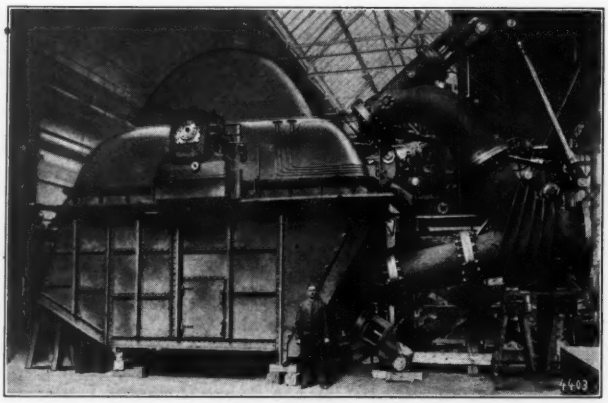
POWER PLANT ENGINEERING February 1933

Beer, Thrustors, Pipelines and Korea

WHAT ABOUT BEER? Will 3.2 per cent beer help business? Will it open up a new field for investment and will it bring orders to manufacturers of equipment? Will it give employment to large numbers of men and women now idle? Will it, in restoring an old industry, give life to other industries? Will it help the railroads, the farmer, the butcher, the baker and candlestick maker, and if so to what extent?

We don't know the answers to any of these questions nor does anybody else, but everybody thinks they do and is talking about them, so to be "in the swim" among other things in this issue we present an article on the Brewery situation as it affects the power plant field. In the preparation of this article we made a rather thorough study of the brewing situation as it exists in Chicago. Our editors visited all the important plants now in operation, talked to the executives and engineers and in this way found out what they are thinking about the situation. We found all of them quite enthusiastic. If legislation is passed legalizing the manufacture of 3.2 per cent beer (4% by volume) all of them believe that it will do a great deal to stimulate business generally and many of them contemplate improving and enlarging their plants. Four per cent beer, they say, is excellent beer—considerably better than most beers made in this country before prohibition, and the brewers expect a large volume of business.



So much for the brewing situation. Now, let's talk about something else. For instance, what do you know about "Thrustors?" Would you recognize one if you met it on the street? Well, we don't expect that you will meet one there, although from the diversity of their application you are likely to run across them almost anywhere—they are so useful. Take pulling nails for example. You know what a disagreeable task it is to pull a lot of nails out of old timber. But don't worry—now we have Technocracy—and from now on the Thrustor will pull nails for you, or if you prefer, it will open or close valves, operate a skip hoist, stop an elevator, squeeze oranges or crack nuts. Indeed, it will do almost anything you can ask of it. Thrustors—what are they? Oh well, turn to page 85 and see for yourself.

Now ponder over this one. About how long do you suppose it takes a "gob" of gasoline to make its way through the 1500 mile Great Lakes pipe line running from Oklahoma to Illinois, under a pumping pressure of 800 lb.? Two days? Three days? A week? Well, one guess is as good as another but if you want the correct answer you will find it in the article describing this line on page 94. There is more to this business of pipe line pumping than one may think, offhand. You may say, "Who cares how long it takes?" Well, the oil dispatchers do for one thing—they have to know where a particular shipment of oil is within a few hundred feet—where the head of each shipment is so that the shipper will receive the same gasoline he delivered to the line.

From Oklahoma and Illinois, let's direct our attention to the Far East. We hear a lot about what is going on out there, though there is much nonsensical discussion about it. But we are not going to talk about the Japanese situation—after all the Japanese are only doing what every other large power, including ourselves, have done repeatedly in the past and their actions should not surprise us—we want to talk about Korea. Korea, if you know your globe, is a peninsula which sticks out from the Asiatic mainland between the Yellow and Japan Seas. It is a mountainous country and as is usual in mountainous countries near the sea coast there are in Korea large rivers. And where there are large rivers we may expect hydroelectric developments. So it is that in Korea recently there has been constructed a large hydroelectric plant—the Fusenko plant—and in this plant are installed Pelton wheels which, so far as we know, are the most powerful in the world, capable of developing 50,000 hp. apiece. That is a lot of power to develop in a single wheel. As might be expected, they are large in proportions. We show one of these wheels in the accompanying photograph as it looked in the shops of Voith in Germany before it started out on its long journey to Korea.

Just as we go to press comes the announcement that the N. E. L. A. is no more. In its place is a brand new association with the classy name Edison Electric Institute, which as far as we can figure out is composed of the same interests but with a new constitution. We don't know all the reasons for this but apparently the industry is endeavoring to do its own housecleaning and are seeking to eliminate many of the practices which have caused criticism of the utilities on page 104 we present a brief account of this change and some of the principles upon which the new association is to be founded. Definite details of the dissolution of the N. E. L. A. apparently have not been announced.

WITH THE EDITORS

Oil Engines

ONE OF the few bright spots in recent transportation progress is the development of the oil electric locomotive. Safety, silence, freedom from soot and reliability are characteristics of the new machine. Economical in operation, the machine can be used in tunnels at railroad terminals, switching service, terminal areas and branch line service and its value has been proven by five million car miles and one hundred thousand locomotive-hours in service.

It is not in the railroad but in industrial plant service that the value of these machines should be most apparent. Studies in this service have shown savings of 50 per cent in operating costs over steam locomotives. During 1931 one locomotive in steel mill service operated 8345 hr. at an operating cost of $4.307 per hour and an availability of 96.3 per cent. Costs for a steam locomotive in similar service were $7.80 per hour. Such performance cannot be overlooked by the industrial plant interested in cutting internal transportation and switching charges and the oil engine in this service is bound to become as important a factor as it already is in the power generating field.

Food or Fuel

FUEL FOR THE POWER PLANT is still the principle item of expense in steam generating plants and the unfortunate phase of the situation is that our most popular fuel—coal—is not being replaced in nature as rapidly as it is being mined. In other words we are rapidly depleting the supply of heat nature has stored up for us during countless past ages. Oil as a source of fuel is subject to this same objection only to a more acute degree than coal. What will be the source of fuel for industrial and domestic purposes 100, 1000 or 10,000 yr. from now is, perhaps, not our immediate concern since our most economical fuel is here in abundance, nevertheless, things are even now shaping themselves so that certain industries can use readily replaceable fuels to advantage.

In the wood working industries hogged fuel and sawdust have been used for years to furnish the necessary power and heat for their factories. Timber does take considerable time to grow and vast areas of land, much of which fortunately has no other use, are required to produce our present needs but unquestionably wood for fuel could be provided at less cost than it is today if industry found it advisable to do so.

In the cane sugar industry bagasse has proved to be the most economical fuel in many instances. Likewise oat hulls and straw have found places in the industrial field where they can be used as fuel to the partial exclusion of coal and oil.

Today our attention is arrested by a news item stating that corn is being used with coal as fuel in an Iowa factory. The president of the company, Automatic Washer Co., Newton, Ia., urges other manufacturers to follow this example as not only an economical measure but as a corn surplus reducer, price raiser and the best kind of farm relief.

Indirectly farmers have always used corn and oats, hay and other roughage as power reducers when they depended upon animal power for working their land. The efficiency of such use is extremely difficult even to estimate but it is probably so low that if it were known, animal power would pass completely out of the picture—a condition which is now actually approaching and is one of the major causes of over production.

Rather than burn corn direct as fuel in boilers and furnaces, which would seem to be not only a waste of farm labor and use of land but an extravagant use of food material, a more logical procedure would be to use the required grains for foods either raw or processed and employ the surplus for the manufacture of industrial alcohol to be used in internal combustion engines for power to work farms and run industrial plants, or for heating purposes as well, if such fuels could be processed to compete in price with other available fuel. This idea is old but until economic conditions force changes in practice many workable ideas lie dormant. As stated above fuel is the big item in power generation, if it can be reduced in cost by the use of agricultural crops or byproducts of industrial processes a definite step forward has been accomplished.

Aviation and the Power Industry

DURING THE PAST few years aviation has increased at a remarkable rate in spite of business conditions. This has not been without its effect on the power industry because transmission lines, towers and smoke stacks are a source of danger to pilots. This is especially true in the neighborhood of flying fields where planes are likely to be flying low.

A number of accidents from this source have been reported, a rather humorous incident of this kind in New York some time ago resulting in a double lawsuit. The power company sued the pilot for damaging a tower and the pilot filed a counter charge alleging that the company was careless in not maintaining warning lights on the tower. The court dismissed the counter charge and the jury decided that the accident was the result of an emergency and the pilot not liable for damages.

In another instance, 250-ft. stacks on a proposed station had to be reduced to 185-ft. because of the proximity to a flying field. Flying fields are increasing in number and importance and furnish another factor that must be considered by designers when planning stations. Although apparently unimportant, it is a point that may lead to expensive changes later on.

POWER PLANT ENGINEERING February 1933

POWER for the BREWERY

Power Plant of the Atlas Brewing Company in Chicago an excellent example of an up-to-date brewing plant. Power requirements of the present-day brewery are much greater than they were before prohibition due to changes in processes.

BECAUSE OF THE INTEREST in the passage of legislation permitting the legal manufacture of beer having an alcoholic content considerably in excess of that now permissible, brewing interests throughout the country are seriously contemplating putting their plants in shape so as to meet the expected demands for this product. Such rehabilitation of plants involves not only the brewing plant itself but also the power plants associated with them.

The power requirements of a brewery are particularly adapted to those which can be provided by a privately operated plant, and in the past breweries were operators of large and well-kept plants. Because of this close tie-up between the brewing process and the use of steam and power, it is to be expected that there will be considerable activity not only in the established breweries but also in the construction of new breweries.

A number of the established plants which have been manufacturing low alcoholic content beer during the period of prohibition, however, have kept their plants up-to-date and such plants today, although they will have to install additional new equipment to meet increased demands are good examples of what the power plants of rehabilitated breweries will consist of.

An excellent example of this type of plant is that of The Atlas Brewing Co. in Chicago. This company has been in continuous existence since 1890. At the time the prohibition law went into effect in 1919, there were some 54 brewery plants in Chicago and while most of these were closed, the Atlas Company was one of about six which continued operation in accordance with the modifications of their product imposed by the government. Since then they have been the leaders in this industry and as the demand for their product rose they expanded their plant and also the power plant.

Until about five years ago, few changes were made in the power plant. It remained essentially the typical brewery plant it had been for 42 yr. and the equipment, though old, operated satisfactorily. True, it was

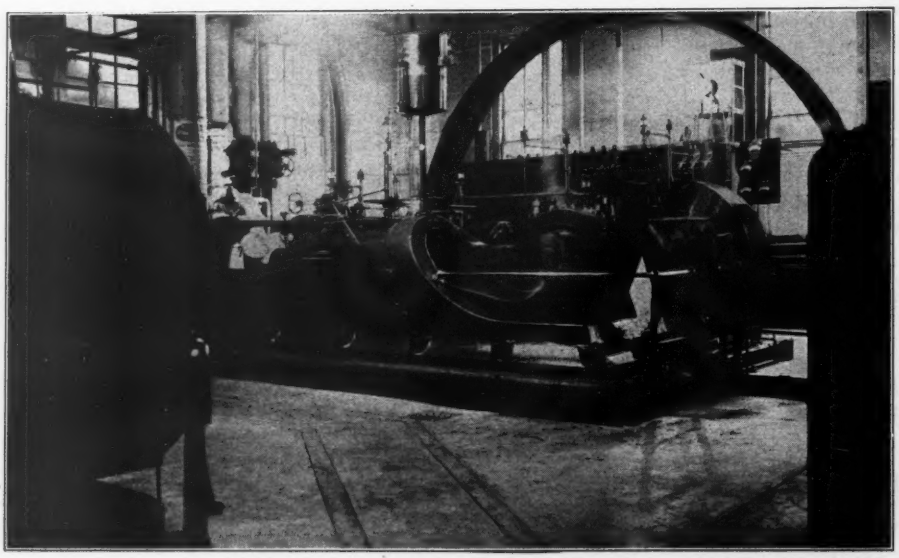


FIG 1. One of the Old Refrigerating Units at the Atlas Brewing Co.

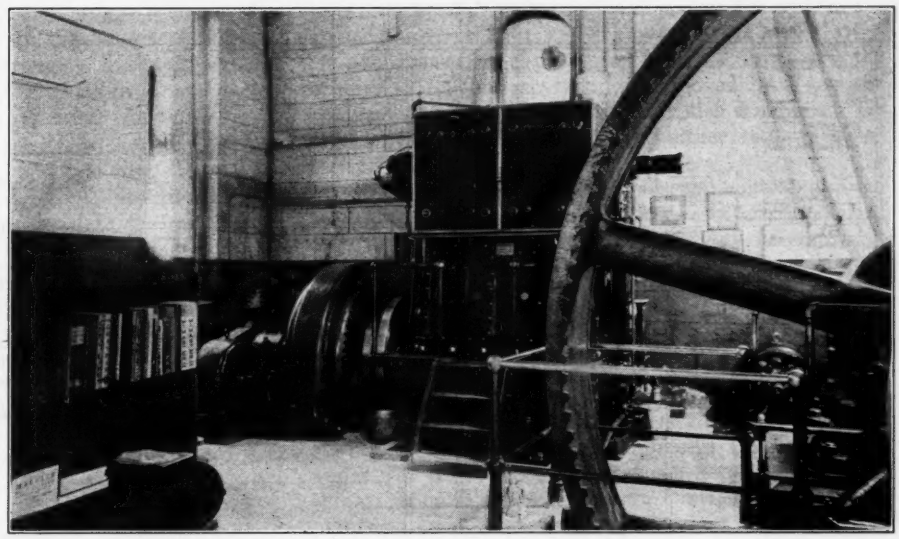


FIG. 2.
New Generating Unit at the Atlas Plant.

not economical as modern economy goes, but in the brewing industry, as in many other industries, reliability and continuity of operation is usually of greater consequence than high economy. It is of less import to save a few dollars by high boiler and furnace efficiency than it is to insure a continuous output of power, for, a case of failure may result in the loss of thousands of dollars worth of product. This, of course, is true of many industries but it is perhaps more so in the manufacture of such a delicate product as beer, the quality of which is affected by very slight changes in the processes. Beer is an extremely delicate beverage and it is only by exercising the utmost care and cleanliness that a good product can be obtained.

This, however, does not mean that a power plant serving a brewery should not be efficient—indeed in a brewery plant the question of economy occupies the same relationship to continuity of operation that it does in any other plant; in other words, the highest economy must be maintained that is consistent with reliability.

History of The Atlas Co.

At the time prohibition went into effect in 1919, the power plant of The Atlas Brewing Co. consisted essentially of four 150-hp. return tubular boilers, 2 Corliss engine driven ice machines, and a small slide valve engine driving a direct current generator.

At this time the "Atlas" was a comparatively small neighborhood brewery with a low overhead, and so when prohibition was established, and the demand for beer in its modified form dropped to a small proportion of what it had been, this plant, by virtue of its small overhead, was able to continue while the larger breweries were compelled to shut down. For several years thereafter it continued to operate with the existing equipment but during that time the modern system of dealcoholizing was perfected, which made a much more palatable near-beer. This dealcoholizing process was developed by Zahn and Nagel and The Atlas Co. was one of the first to use it. The improvement in the quality of the product effected by the new dealcoholizing process soon created an increase in the demand for beer and so in 1923 two new boilers were added, one a 240 hp. and the other of 325 hp. capacity.

These served to carry the increased load for several years but about five years ago production had increased and was increasing to such an extent that it became imperative to extend the power plant facilities very considerably. So, a careful study was made and plans drawn up for a complete revamping of the power plant.

The two existing ice machines of about 100 t. each were still in excellent shape so it was decided to retain them. In addition, another machine was purchased. This was not a new machine, but a second hand unit of 125 t. capacity which was obtained at a reasonable figure from a discontinued plant.

At this time the boiler plant consisted of 6 H. R. T. boilers, four old 150 hp. units and the two new units installed about 1923. The four 150 hp. units had about reached the end of their useful life, so it was decided to scrap them and replace them with two new water tube units of much greater capacity.

To effect this change, it was necessary to alter the entire layout of the plant. The two original ice machines were left in place, but to make room for the third unit a new engine room was made out of the room containing the four boilers which were scrapped. To house the new water-tube boilers, a building which had served as a warehouse was remodeled and converted into a new boiler house. This building was adjacent to that portion of the existing boiler room which contained the two H. R. T. boilers to be retained.

In addition to these changes it was also decided to install a new electric generating unit to replace the direct current unit. Since the plant had expanded, most of the current used had been purchased from the Commonwealth Edison Co., so a new alternating current generating unit was purchased and installed in the location shown on the accompanying drawing. This unit consists of a four cylinder Ames, vertical uniflow engine direct connected to a 200 kv-a., 240 v., 3 phase Crocker-Wheeler generator having a Ramsey silent chain belt driven exciter. At the same time, the switchboard was remodeled to handle alternating current and a new generator panel installed.

These changes gave the plant sufficient steam generating capacity for some time to come and also satisfied a considerable portion of the electrical requirements, but

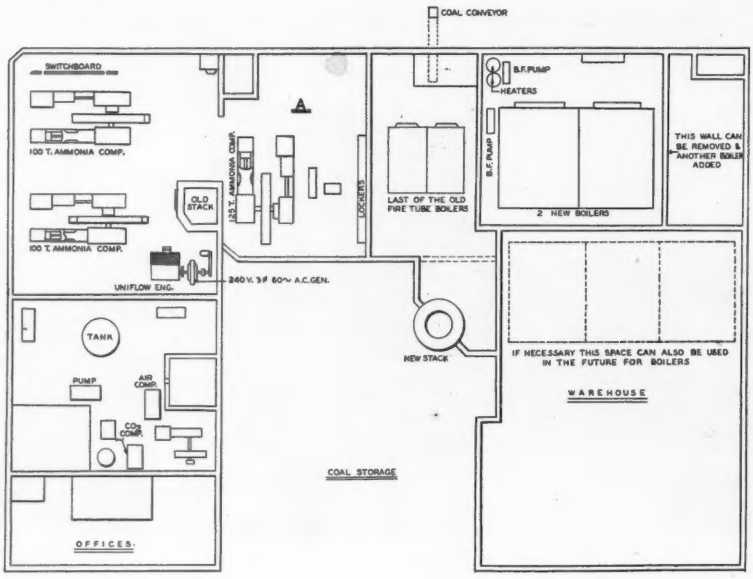


FIG. 3.

Plan, Showing the Present Arrangement of the Power Plant.

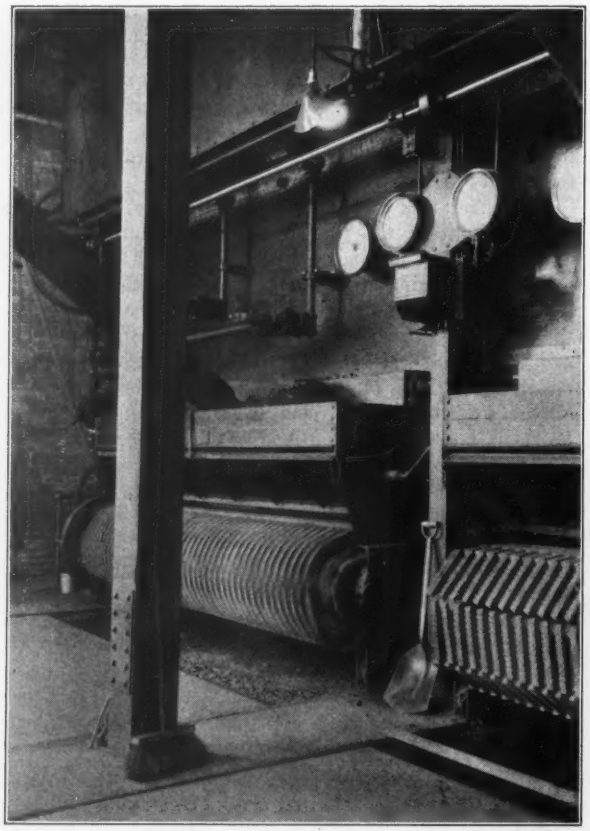
The space now occupied by the 125-t. ammonia compressor shown at A was the old boiler room. The four old boilers which occupied this space were removed and the new compressor installed. There is ample room for further expansion as will be wanted; if necessary the warehouse which now backs the new boiler room can be used for power plant purposes.

not all—a certain amount of current is purchased. At the present time, however, the electrical load has increased to such an extent that a new generating unit is to be installed. Space has been provided for this. When the plant was remodeled, the possibility of a second generating unit was foreseen and not only was space provided, but the switchboard foundation was extended to accommodate the future generator panel.

The present plant, therefore, consists of a new boiler room, an old boiler room and an enlarged and remodeled engine room. These are all at the grade level.

As was stated, the new boiler equipment is housed in an old building which originally served as a warehouse. The method of installing the boiler equipment was rather unique. Instead of using the building walls or structure for the support of equipment, an entirely new steel frame structure was erected within the old warehouse and all equipment in the boiler room which is not supported from the foundation is supported from this steel framework. This arrangement can be seen in the drawing, Fig. 7. The two floors of the old building were cut away so as to provide room for the new boilers which extend upward to practically the full height of the building. This provided a very satisfactory solution to the building problem. The walls of the old building were still in excellent condition but it was realized that they were unsuitable for carrying the heavy loads of modern boiler equipment.

The two new boilers are Burton bent tube boilers, rated at 600 hp. each, baffled for three passes and fired



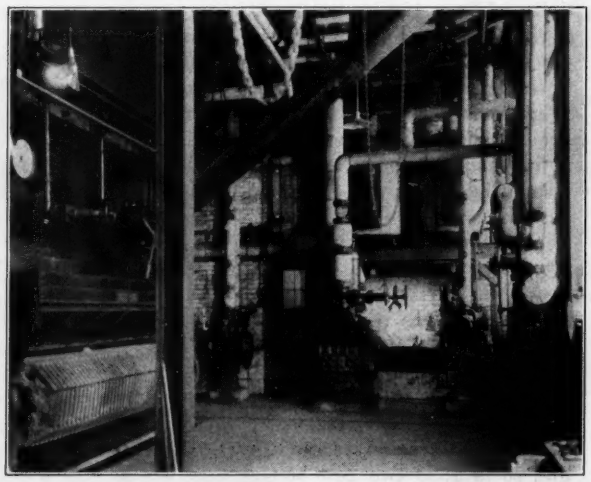


FIG. 4 AND 5. TWO VIEWS IN THE NEW BOILER ROOM

by Burke Engineering Co. chain grate stokers. The stokers are designed to operate the boilers at 200 per cent rating and are driven through a line shaft extending across the front of the boiler which in turn is driven by a small vertical F. H. Wachs steam engine.

These boilers operate at about 125 lb. steam pressure and under normal conditions a single unit can supply the needs of the plant. The two old fire tube boilers which were retained are connected into the same headers, however, and are used largely as incinerators for burning dried hops and other refuse.

The arrangement for delivering coal to these boilers is interesting. The old boilers were, and still are, hand fired. When the new boilers were installed, overhead steel coal bunkers were provided and a new coal handling system was desired. The question of expense, however, was a vital item and upon investigation it was found that the cost of orthodox systems available was higher than that which could be justified. So other schemes were considered. The one finally selected is simple, effective and inexpensive.

Coal is delivered to this plant by railroad cars which can be placed immediately outside the boiler room. A small trench was therefore cut underneath the tracks at right angles to them, which extended inside the boiler room. Next, a small portable drag conveyor was purchased, the wheels removed, and this permanently installed in the trench, so that coal dumped on to it at one end is carried into the boiler room. Inside, this conveyor delivers to a Conveyor System Inc. bucket elevator which in turn carries the coal to the upper part of the new boiler room where a flight conveyor distributes the coal into the bunkers.

For a plant of this size this was a satisfactory solution to the coal handling problem and since its installation several years ago it has operated satisfactorily. The portable conveyor is capable of handling about a ton of coal a minute. At the time the work was done the lowest priced standard coal handling system available would have cost around $6000. By the use of the system installed the entire cost was kept within $1500.

Ash disposal is equally simple. This drops into the ashpits in the basement and is removed by Conveyor Systems, Inc. drag type conveyor which dumps into an elevator so that it can be loaded either into trucks or cars.

Boiler operation is under manual control and no forced nor induced draft fans are installed. Sufficient over fire draft is provided by a 175 ft. tile stack, installed by the Heine Chimney Co.

Each boiler is provided with a Republic boiler meter and an Ashton indicating steam pressure gage. A Republic 4 point draft gage indicates the draft pressures over the fire and in the last pass of both boilers. There is also installed a Republic recording CO_2 recorder and a Republic recording water meter, measuring the feed supply to the boilers. At the present time plans are under way for the installation steam flow meters so that the amounts of steam supplied to various parts of the plant can be more accurately determined.

Feedwater

Boiler feedwater is first heated and treated in a large tank having a capacity of about 9000 gal. This water is principally the overflow from the hot beer coolers and normally it enters the tank at about 120 to 130 deg. F. In the tank it is further heated by exhaust steam to about 140 or 150 deg. In the summer when plenty of exhaust steam from the refrigerating machines is available, the temperature of the water in this tank will run as high as 170 and 180 deg. Treatment consists of adding a compound containing a trisodium phosphate base and permitting the sludge to settle.

No condensate of any kind is used for boiler feed purposes—all condensate goes to the sewer. The reason for this is that a large amount of live steam is used in the brewing process, there must be no possibility of contaminating the water in the boiler from the use of condensate containing oil or other foreign matter.

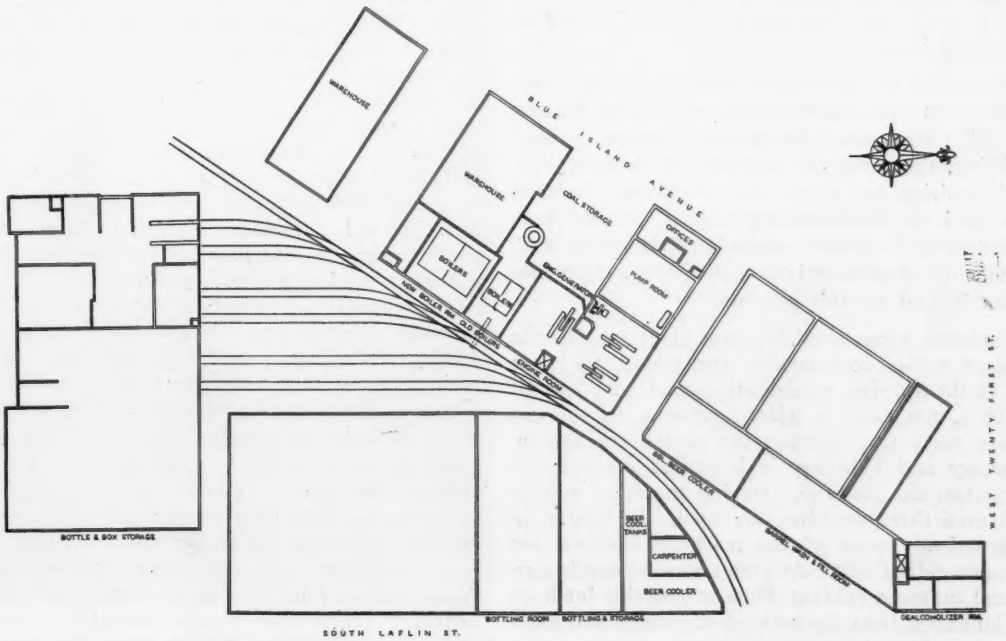


FIG. 6. PLAN OF ATLAS BREWING CO. SHOWING RELATIVE LOCATION OF THE POWER PLANT

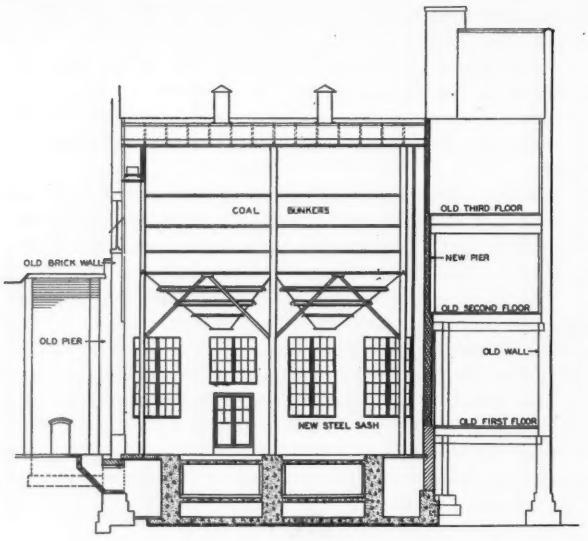


FIG. 7. ELEVATION OF THE NEW BOILER HOUSE SHOWING HOW SEPARATE STEEL FRAMEWORK WAS CONSTRUCTED INSIDE OLD BUILDING

This storage tank is located in a room above the engine room. From here it flows by gravity to the boiler feed pumps to the boiler room, which pump it through two Reilly, closed type feedwater heaters into the boilers. In the feedwater heaters the temperature is raised to around 180 deg. and higher in summer. Two feed pumps are installed. These are 16 x 9¼ x 16 in. simplex steam pumps made by the American Steam Pump Co.

So much for the power plant proper. Now let us discuss more in detail the service which such a plant as this must be capable of delivering. As has been implied, the brewing process is a highly delicate process and it is dependent upon an unfailing supply of power. If at a vital time the steam and power supply were shut off for even a short time, thousands of dollars worth of product would be spoiled.

Steam is used for various purposes at various pressures. Both live and exhaust steam are used for heating water, boiling beer, etc. Live steam, of course, is used for pumping, operating air compressors, engines, boiling, dealcoholizing and many other purposes. Exhaust steam is used for dealcoholizing only in summer time when, because of the great increase in refrigerating load, a large amount of exhaust is available. In winter time live steam is used for this purpose.

The exhaust steam available in a plant such as the Atlas plant varies considerably throughout the year because of the varying refrigerating load. At present about 100 t. are used in winter, whereas in summer 350 t. are necessary. During the months of December, January and February it is seldom necessary to use more than one machine. During the other months two and even three machines are used. In winter, at night, practically none of the machines operate, not even the generating unit. At such times current is purchased and sufficient exhaust steam is available for heating the buildings from the boiler feed pumps and other steam pumps throughout the plant.

Power Requirements Greater Than Before Prohibition

In considering this use of power in the brewery plant, it is interesting to know that with the legalizing of 4 per cent beer, the amount of power required will be greater than it ever was before prohibition, despite the fact that the steam now used for dealcoholizing will be saved. This is due to the fact that the processes are more complicated, more automatic machinery is involved.

The modern brewery to meet competition must use modern methods, automatic bottling machinery, washing and labeling equipment, conveying equipment and a score of other power driven devices which the old time brewery did not have. Before prohibition in the average brewery only about 30 per cent of the beer was sold in bottles—70 per cent was distributed in kegs or barrels. Today just the reverse condition prevails—70 per cent is sold as bottled beer while 30 per cent is sold in kegs.

These changes will have to be given serious consideration in any plant which is to be rehabilitated. If a plant which has been shut down, say, since prohibition was established, is to be placed in operation again today, for the same output, considerably more power would be required now than before. Indeed, the entire power plant in such a plant will have to be revamped to a considerable extent. Most of the older plants used hand firing and in the smaller breweries, as in the case of Atlas, fire tube boilers were used.

Today, undoubtedly, these plants would have to replace these hand fired, fire tube units with stoker, pulverized coal or oil fired, water tube boilers with modern instruments and control systems. Associated with such new boiler installations, improved coal and ash handling systems would be in order, and in many instances forced and induced draft equipment. The feedwater heating and pumping systems probably would be obsolete and consequently would be subject to considerable revamping.

In the engine room the alterations necessary would not be as extensive perhaps but still changes would be made. The refrigerating machines for the most part could be used but the generating units would no doubt be replaced, as was the case in the Atlas plant. Most of the old breweries used direct current, but modern equipment is more adaptable to the use of alternating current equipment and almost any rehabilitation program will include the conversion of direct to alternating current.

An interesting feature of the Atlas plant is in the pumping and compressing equipment used in the plant, particularly the beer pumps. In the early days when a brewer needed a pump, nothing but a "brewer's" pump would do—no other type of pump was ever considered. These pumps were manufactured by firms who specialized in that type of equipment and the cost was high. An ordinary centrifugal beer pump driven by a 3-hp. motor cost on the average of $500.

In an endeavor to reduce investment cost and to improve operation at the Atlas plant several years ago an attempt was made to adapt ordinary pumping equipment to the brewing process. The manufacturers of standard pumping equipment were reluctant to supply such equipment and so it became necessary for the Atlas engineers to experiment themselves. By buying ordinary centrifugal pumps intended primarily for water service, and by the use of special metal fittings,

such as bronze and stainless-steel, they soon succeeded in making excellent beer pumps out of standard water pumps at a great reduction in cost. A pump for this service which formerly cost $500 now is installed for $150 by merely ordering a standard pump and specifying stainless steel shafts, sleeves and wearing rings. The new stainless steel liners last just about ten times as long as the bronze liners formerly used.

A similar condition exists regarding compressor equipment. In the manufacture of beer it is exceedingly essential to keep grease or oil of any kind away from the process. For this reason ordinary oil lubricated air and CO_2 compressors should not be used. For years, therefore, a special type of air compressor had been used, using water lubrication and for CO_2 service, a compressor using a special "white" oil has been used. At the present time, however, the firm of Zahn and Nagel, which developed and perfected the modern dealcoholizing equipment, has developed a new type of water cooled and water lubricated air or CO_2 compressor, which will soon be installed in the Atlas plant. These compressors are a considerable improvement not only because of the entire absence of oil, but also because of the cooling effect of the water. This is of especial advantage on the CO_2 compressors. The CO_2 is extracted from the fermenting tanks and after being compressed and passed through a scrubber it is bottled in cylinders under 250 lb. pressure for carbonating purposes. If the CO_2 is raised to too high a temperature during compression, however, it is "burned" and gives an undesirable taste which is noticeable in the final product. In the ordinary oil lubricated compressor, it is difficult to keep the temperature below 140 deg. F. which is necessary but with the new design whereby the heat of compression is eliminated in the cylinder during the compression stroke, this is easily effected.

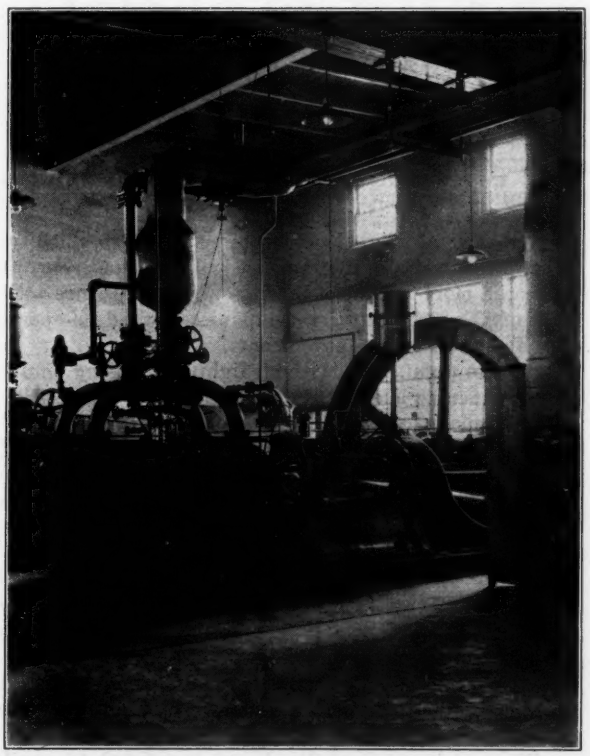


FIG. 8. THE NEW 125-T. AMMONIA COMPRESSOR. SPACE FOR NEW GENERATING UNIT IN THE FOREGROUND

This completes this discussion of the use of power in the brewery plant and while no attempt has been made to make it comprehensive, it is hoped it gives a representative picture of the relation of the power plant to the brewery at the present time. In presenting this article we acknowledge our indebtedness to the engineers and officials of the Atlas Brewing Co., particularly to N. O. Kenniker, the chief engineer, and to Charles Elman, the brewmaster, for valuable assistance in collecting information and for photographs and drawings which appear in this article.

Interest and Depreciation Charges

By James O. G. Gibbons

Referring to the communication of Gordon R. Hahn, in the December issue, on Fixed Charges vs. Fuel Savings, he did not include in his discussion the correct method of estimating the fixed charges due to interest and depreciation and, as these are often incorrectly figured, it may be worth while to give this matter further consideration.

The method often employed, probably because it appears rather obvious and will generally pass without further discussion, is to add together the interest on the original investment and the annual depreciation, and charge the sum to fixed charges.

This method is not correct, for if a charge is made for depreciation the sum allowed should be carried to another account, when it may either be invested in interest bearing securities, or left in the business and an interest charge made against the business, but in no event should this interest be charged against the original investment.

If this problem is correctly handled, it becomes similar to that of an amortized mortgage on which yearly interest is paid only on the outstanding balance.

As an illustration, let us consider the case of a machine which is depreciated from $1000 to zero in 10 yr., with an interest charge of 6 per cent per annum.

Depreciation charge is $100 a year, and by the incorrect method the interest charge would be 6 per cent of $1000, or $60, making a total of $160, which is too high.

If we made the depreciation charge daily, the average investment standing against the machine would be half of $1000, or $500, making an average interest charge of $30 instead of $60 and the total charge of $130 instead of $160, a difference of $30.

Usually the practice is to figure the equivalent average interest rate on the original investment which in the above case would be 3 per cent of $1000 which gives the same result, but as the depreciation charge is generally made at the expiration of each year, the approved equation is as follows, assuming that the investment is written off in M years, and the interest 6 per cent.

$$\text{Average interest} = \frac{M+1}{M}\left(\frac{\text{investment} \times 0.06}{2}\right)$$

which in this case equals 3.3 per cent, making a total annual charge of $133.

POWER PLANT ENGINEERING February 1933

Turbine Designs *to meet* Industrial Conditions

Modern Turbine Types Available to Meet the Complex Demands of the Industrial Plant for Electric Power and Process Steam in the Plant

PROPERLY DESIGNED industrial power plants should be much more efficient than utility central stations because the condenser loss can be greatly reduced or, in some cases entirely eliminated. Given credit for the heat in the exhaust a back pressure installation can with good boiler efficiency make a kilowatt hour for about 4500 B.t.u. whereas the best central station, with a much greater investment, cannot make a kilowatt hour for much below 12,500 B.t.u.

With the single objective of making electric power as cheaply as possible, the central station is more or less limited in equipment selection. The industrial plant on the other hand must supply not only electric power but heat and process steam sometimes at several different pressures. This heat is a necessary part of the industrial process and in but a few cases can the necessary steam be purchased.

By-Product Power or Steam

Electric power on the other hand can be purchased in practically every locality for around $0.01 per kw.-hr. Under these conditions power generated by partial expansion of steam for process is generally called by-product power. There is some difference of opinion as to whether the steam or power is the by-product but this somewhat meaningless controversy has no bearing on the engineering involved.

Unfortunately it is extremely difficult to make the electric and steam loads coincide so that all the exhaust steam can be reclaimed but development of the steam accumulator and the availability of central station power at competitive prices has opened up new avenues of approach for the industrial engineer.

Methods of Balancing Loads Includes Condensing and Noncondensing Operation

Four methods of balancing the steam and electric loads are now used. The oldest and perhaps the most common method is to design the plant for the steam requirements with sufficient condensing capacity to take care of the unbalanced electric load. Steam demands above the turbine exhaust is taken care of through reducing valves.

A second method is to install steam and electric drives so that the two loads can be balanced to a certain extent. With the increasing popularity of motor drives flexibility offered by this scheme is decreasing. The steam accumulator also has been used to balance loads somewhat and used in conjunction with the drive arrangement mentioned above to take care of long load savings is effective.

Perhaps the most popular scheme at the present time is to design the plant for the steam requirements putting in sufficient back pressure generating equipment to take care of this steam demand and purchase the balance of the electric power from the utility. Whether this or the first scheme will eventually prove to be the more practical depends upon the future attitude of the public utility companies toward co-operation and interchange agreements.

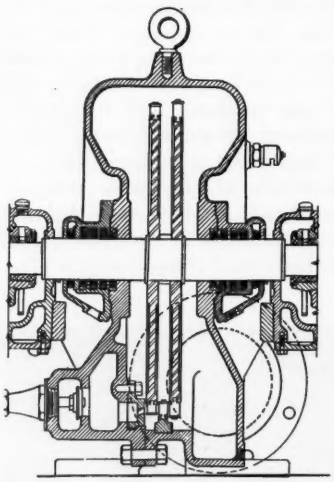


FIG. 1. MECHANICAL DRIVE TURBINE WITH TWO WHEELS

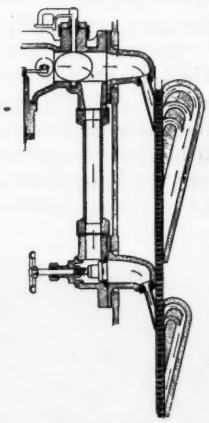


FIG. 2. RETURN GUIDES ON A SINGLE WHEEL

Private plants can, with straight condensing equipment, generate electric power at prices competitive with purchased power. Each pound of steam used for heating and process increases the thermal efficiency of power generation, the ultimate limit of this increase being a straight back pressure operation, which gives a fuel cost of 1/3 to ¼ that of the utility company.

Turbine Types

Practically all turbine manufacturers make many types of turbines. From these many types and makes a few have been selected to show fundamental differences in design and construction. Simplest and most common of the turbines are as shown by Fig. 1, usually known as the mechanical drive type.

These units are usually direct connected to auxiliaries, sometimes through a reducing gear so that the

turbine can operate at its more efficient high speed and still drive a low speed machine. These units are built in different arrangements of pressure and velocity staging with one or more wheels. The one shown by Fig. 1 has two rows of moving blades. Sometimes one row of blades is used with the steam reversed in guides as shown by Fig. 2 so that it passes through the buckets two or more times before being exhausted. Both of these drawings show hand operated auxiliary valves common on this type of machine. Closing these auxiliary valves at partial load gives a steam economy appreciably above that which would be obtained through throttling. These machines are primarily for back pressure or non-condensing operation.

In the larger machines more wheels are used, Fig. 3 showing the arrangement of a nine stage back pressure

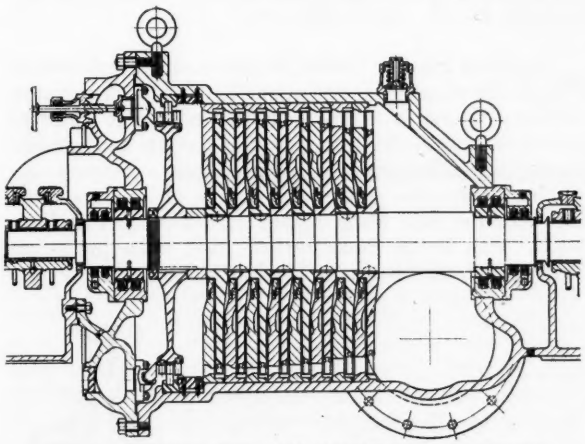


FIG. 3. MEDIUM SIZE NON-CONDENSING TURBINE

unit. Further extension of the pressure range to include condensing operation makes it necessary to increase the length and size of the blading in order to take care of the greater specific volume of the steam to be handled at the low pressures. Figure 4 shows a small condensing turbine of the impulse type.

Both impulse and reaction type turbines are in wide use. Fundamentally an impulse blade is shaped symmetrically as shown by Fig. 2 and is turned by the impact or velocity of a jet of steam from a nozzle. A reaction blade is shaped so that the blades themselves form

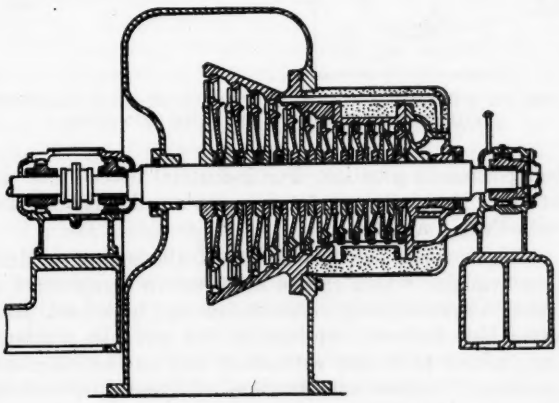


FIG. 4. CONDENSING TURBINE

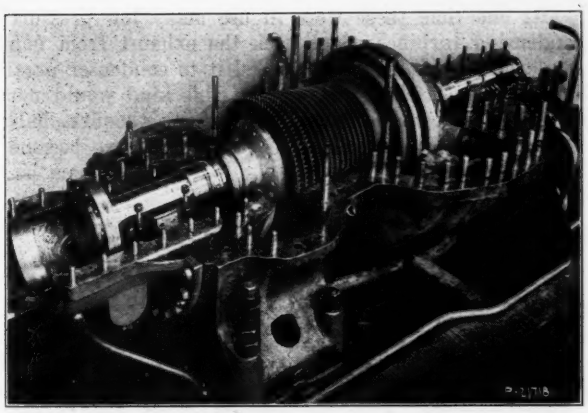


FIG. 5. REACTION TURBINE ROTOR WITH TWO IMPULSE WHEELS

the nozzle and the wheel is turned by the reaction of the jet of steam leaving the blades or nozzles. The shape of these blades can be seen from Fig. 5, a small reaction turbine with two impulse wheels. Use of these two wheels shortens the spindle considerably over a straight reaction design.

Low Pressure Turbines

Sometimes, especially on the larger turbines, it is convenient to build the turbine in two or three sections. The layout of a cross compound unit of this type is shown by Fig. 6. Exhaust from the high pressure element is taken by the low pressure element and further expanded to the exhaust pressure.

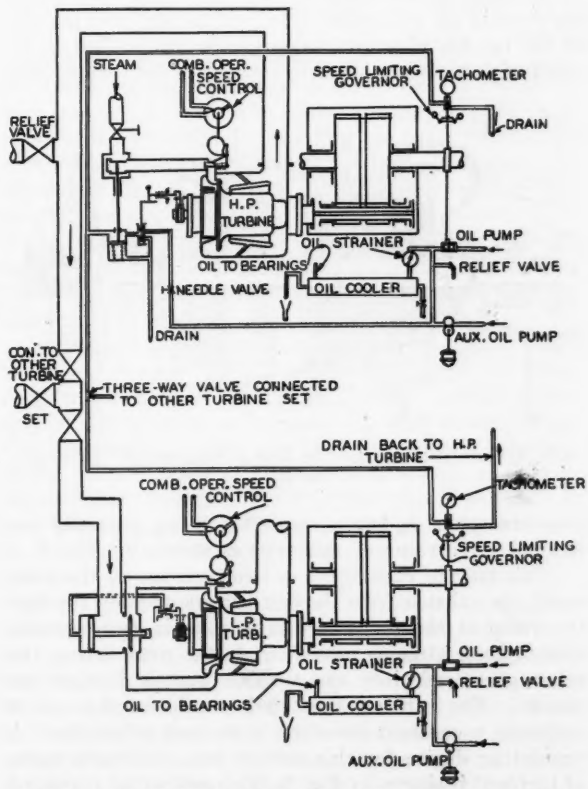


FIG. 6. ARRANGEMENT OF COMPOUND TURBINE FOR AUXILIARY DRIVE

At one time there were in use many low pressure condensing turbines which took the exhaust from non condensing engines and expanded it to condenser pressure. In appearance a turbine of this kind would not differ greatly from that of Fig. 4 with the first half removed. As conditions changed and turbines became more popular the proportion of low pressure steam be-

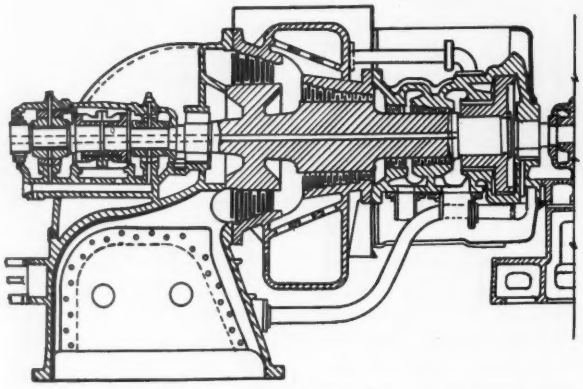


FIG. 7. SECTION OF A MIXED PRESSURE TURBINE. LOW PRESSURE STEAM ENTERS AT B

came less and the low pressure section was combined with a regular turbine as shown by Fig. 7. This type of turbine is known as a mixed pressure type and uses both high and low pressure steam, the latter entering midway of the cylinder. Figure 7 is reaction turbine and a comparison with an impulse turbine Fig. 4 will show the differences in construction.

Perhaps the most important of the modern industrial turbines is the extraction type, which can be explained as the reverse of the mixed pressure type. That is instead of putting low pressure steam into the turbine, low

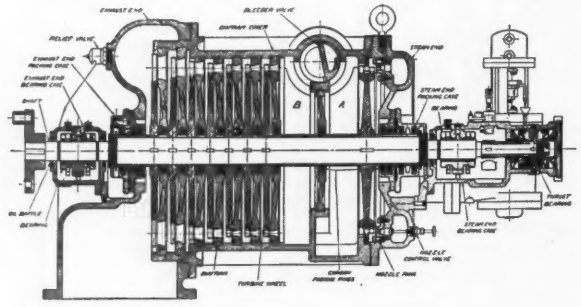


FIG. 8. BLEEDER TURBINE WITH PRESSURE CONTROL VALVE

pressure steam is taken out after being partially expanded. A turbine of this type is shown by Fig. 8.

This may be considered as two turbines on the same shaft, the exhaust from the first turbine passing through the valve at the top where it is split in two streams. One of these streams passes out to the process line, the other goes back into the turbine and is further expanded. The valve at the top is manipulated so as to maintain a constant pressure in the extraction line. A regulating device for this service (on a different make of turbine) is shown by Fig. 9. This particular regulator is equipped with remote control.

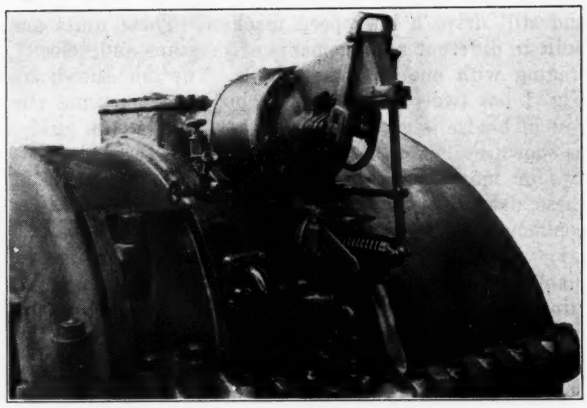


FIG. 9. AUTOMATIC BLEEDER DEVICE WITH REMOTE CONTROL

Turbines are not limited to one stage of extraction, Fig. 10 showing two stage extraction in a high pressure turbine. Steam is taken from two points at different pressures intermediate between the throttle and exhaust conditions. This particular machine has no pressure regulating device, the pressure at the bleeder points varying with the load being higher at heavy than at light loads. This is the usual method used when the steam is extracted for feedwater heating, three or four stages

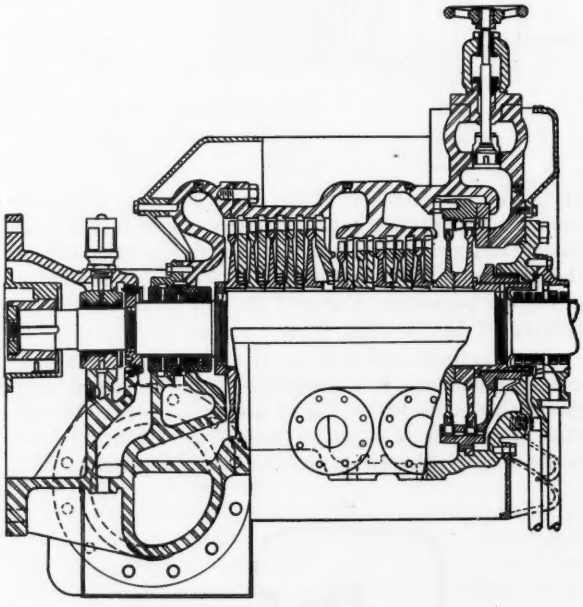


FIG. 10. SECTION OF A HIGH PRESSURE TWO BLEEDER TURBINE WITHOUT PRESSURE CONTROL

being common practice. For industrial process use the pressure is usually regulated as explained in connection with Figs. 8 and 9.

Above types are but a few of the many turbines now available which can be classified in many ways, a common system being: non-condensing; high back pressure; high pressure condensing; low pressure condensing; mixed pressure; extraction and extraction-mixed pressure. Various combinations of these fundamental types can be made to meet local conditions.

Part I. Selection of Fuel Characteristics of Oil with Special Reference to Bunker C and Residuals.

OIL FUEL FIRING *and* Combustion Equipment

By
E. G. Peterson*

IN RECENT YEARS fuel oil prices have been so attractive that many coal burning plants have been converted to oil firing to take advantage of the price differential between coal and oil. This applies not only to hand fired jobs, but also to stoker and pulverized coal installations. Some stoker fired furnaces are so arranged that with the proper burner equipment oil can be fired above the stokers by protecting them with firebrick and insulation. In such cases no change in wall construction is required and the stokers can be placed in service again inexpensively and with little loss in operating time. In other stoker fired plants the change is not so simple; nevertheless, conversion to oil has been found economical and has fully justified the expenditure required for conversion.

In the case of pulverized coal installations, some foresighted engineers had prepared for the burning of oil at the time their plants were laid out by installing combined burners that could successfully handle either coal or oil. Sufficient auxiliary apparatus was installed to provide for oil lighting torches and in some cases for operation of the boilers on light loads with oil. Adequate oil storage space and auxiliaries have since been added for full operation on oil.

It is interesting to note here that the reverse of the scheme is now being put into practice in the design of many plants; that is, oil burning installations are now being laid out with combined burners to provide for future firing of pulverized coal in combination with oil. This point will be discussed further in a future article on equipment.

It is not within the scope of this article to deal with all the factors that must be considered when estimating the economy of converting a boiler plant to oil burning. It will be well, however, to mention some of the most important of these factors and enlarge only on those which affect the selection of the grade of fuel oil to be burned in the plant. These considerations also apply, of course, to new plants in determining the selection of fuel.

Items which eventually determine the kind of fuel for which a new plant is to be designed or an existing installation redesigned, are price and availability of the various fuels under consideration. These items also affect the selection of the grade of fuel and must be considered together. This is naturally so, inasmuch as a fuel obtainable at a low price and requiring certain equipment for its handling will not be attractive unless obtainable in such quantity and over such a period of time that the investment in equipment may be paid back.

In many plants so located that the price differential between coal and oil is not sufficient in itself to make the investment in oil burning equipment attractive, due weight must be given to other important factors such as convenience in storage, handling, and firing; advantages of oil over coal in connection with processes affected by dirt and dust; load characteristics; banking losses; and labor cost.

It is quite impossible to prepare a schedule or chart which will determine, with a reasonable degree of accuracy, whether or not an existing coal burning plant may be converted to oil economically and satisfactorily. This observation applies also to the problem of selection of the proper *grade* of fuel oil to be employed in the contemplated installation. The fact that a certain oil may be purchased at a low price per gallon should not be accepted as the controlling factor in signing a contract.

Each grade of fuel oil has a definite field of application, although the limits within which each grade may be applied are somewhat elastic, depending on local conditions in the district in which the plant is situated. For example, crude oils are being burned in a few plants so situated that such fuel can be obtained more cheaply than ordinary fuel oils. These are exceptional cases, of course, but are mentioned here to indicate the effect of local conditions in the selection of fuel. Light indus-

*Peabody Engineering Corp., New York, N. Y.

trial oils of low pour point and low viscosity are worth a premium price when applied to the firing of small industrial furnaces such as ovens, forges and kilns. These fuels may be burned without heating and may be satisfactorily handled in cold weather in exposed lines without the necessity of heating in the storage tank.

Gravity No Longer Reliable Guide

For the average boiler room the fuel oil sold commercially under the name of Bunker C is generally indicated as meeting the requirements of price and availability. A few years ago the A. P. I. gravity of this fuel was considered a fairly accurate indication as to its more important characteristics such as viscosity, flash point and heating value, although this gravity is not mentioned in the specifications which the fuel must meet in order to be graded as Bunker C fuel. Today, however, gravity has little significance to the average user except that it is a number through the use of which and by reference to the proper tables the weight per gallon may be calculated.

In view of the fact that fuel oil is purchased on a volume basis, that is, as measured by the gallon or barrel of 42 gal., the gravity of the oil is important to the consumer only in that it determines the number of pounds of oil which he receives for a certain sum of money. For instance, he may be offered two oils meeting the same specifications, one of 18 deg. A.P.I. gravity having a heat content of 18,500 B.t.u. per lb., and at the same price a fuel of 10 deg. A.P.I. gravity containing 18,000 B.t.u. per lb. A simple calculation will show him which is the more economical. The high gravity oil, that is the 18 deg. A.P.I. fuel, will weigh 7.88 lb. per gal. and will, therefore, contain 145,980 B.t.u. per gal. The low gravity oil will weigh 8.33 lb. per gal. and will contain 149,940 B.t.u. per gal.

Generally with the same pumping, heating and burning equipment the low gravity fuel can be burned as efficiently as the other, and, assuming that B.t.u. relationship is as illustrated, will produce more steam per dollar than the high gravity fuel. In other characteristics such as viscosity and flash point, the two oils may be very similar and the equipment required for preparation and burning exactly the same in either case.

Low gravity fuel oils now being marketed lie in two general classes; those which meet the A.P.I. specifications for Bunker C fuel and those which do not. The heavy fuels which do not come under the A.P.I. specifications for Bunker C usually are the residue of cracking processes. They generally show more free carbon than the Bunker C specifications permit but this carbon usually is in stable suspension and not objectionable.

Residual Fuels Cheap

Such fuels generally have a higher carbon content and are lower in hydrogen than ordinary fuel oil and hence will give more efficient combustion results due to decreased hydrogen losses. These residual fuels sometimes are blended with more expensive oils to meet Bunker C specifications. When sold without blending they are less expensive and often more efficient than the blended oil.

The question of gravity has been discussed at some length in order to make it clear to the reader that today a high gravity fuel is no more desirable than the low gravity fuel from the standpoint of handling, preparation and burning. Changes in refinery methods within the past few years have completely eliminated the previous significance of gravity in relation to other characteristics and it is important to bear this in mind when making the selection of fuel.

A most important characteristic of fuel oil is its viscosity. This is generally stated in terms of the Saybolt-Furol scale at 122 deg. F. In its application to fuel oil, it is a measure of the resistance of the oil to flow in piping and to atomization. The Saybolt-Furol number corresponds to the number of seconds required for the flow of 60 cc. of the oil from the Saybolt-Furol viscosimeter at a given temperature. This number should not be confused with the Saybolt Universal number which is determined by the use of a viscosimeter having an orifice smaller than the Furol type machine in such ratio that one second Saybolt-Furol (1 S.S.F. as generally abbreviated) corresponds to approximately ten seconds Saybolt Universal (10 S.S.U.). An oil of 300 S.S.F. at 122 deg. F. could also be noted as approximately 3000 S.S.U. at 122 deg. F. The use of two machines is required in the laboratory in order to maintain the discharge rate from the orifice within reasonable limits, thus preventing the introduction of large errors into the tests. The two scales of numbers are maintained in spite of the confusion which occasionally arises, on account of the fact that there is no true mathematical relationship between them, although from 50 S.S.F. upward, the ten to one ratio in scales is close enough for ordinary purposes.

Viscosity Is Important Characteristic

According to specifications, Bunker C oil may have a viscosity as high as 300 S.S.F. at 122 deg. F. Some oils, sold under the same specifications, have viscosities as low as 40 S.S.F. at 122 deg. F. The temperature at which the oil should be supplied to the burners corresponds to about 180 S.S.U. for mechanical atomizers and for most economical operation between 300 and 400 S.S.U. for steam atomizers. The following table gives the approximate temperature corresponding to these viscosities for various fuel oils and is based on actual tests of commercial fuels.

Viscosity at 122 deg. F. S.S.F.	Approximate Temperature Deg. F. Mechanical Atomization	Steam Atomization
300	230	195
200	220	185
130	190	165
70	175	145
60	165	140
40	150	125

Viscosity of the fuel oil as supplied to the plant may be obtained from the vendor of the fuel. By locating this viscosity in the table or by interpolation between the values given above, a fair estimate may be made as to the temperature required at the burners. For more accurate work the viscosity of a sample of the oil should be determined at two or more temperatures and these values plotted on log-log scales. A straight line drawn between two points will be the temperature viscosity "curve." The temperature carried at the heater will, of course, be slightly higher in order to allow for temperature drops in the lines between heaters and burners.

Use of Pulverized Petroleum Coke at Michigan City

DURING the past summer petroleum coke screenings were burned at the Michigan City Station for a period of 3½ mo. because labor difficulties in the Indiana coal fields interrupted the coal supply. The Michigan City Station which was described on page 796 of the December, 1932, issue of Power Plant Engineering has three 345,000 lb. per hr. boilers with slag tap furnaces, economizers, air heaters and electrostatic precipitators. Each boiler has two 12½ t. pulverizing mills. Boilers Nos. 1 and 2 use Kennedy-Van Saun balls mills and Boiler No. 3 Fuller Lehigh type B table mills.

Of the cokes available one was finally selected which had the following analysis expressed in percentage as fired: moisture, 5.66; volatile, 15.02; fixed carbon, 77.15; ash, 2.17; sulphur, 1.27; B.t.u. per pound, 14,925.

This coke did not unload as readily as coal but tended to stick in cars, unloading hoppers and piping, the difficulty being more pronounced in winter than in summer. Besides being hard to unload it was dusty and required wetting in the cars. Fine wet coke tended to stick in the scales causing inaccuracies of 1 to 1½ per cent of the total coke handled.

Occasionally feeder discharge piping had to be cleared of small wire accumulations to facilitate coke flow to the mills. In order to keep these pieces of wire out of the table mills, finer grating was placed over the No. 3 hopper and the mill magnet cleaned frequently. It was impossible to use the automatic sampler. The fine damp coke would pack in the dust, causing sluggish operation and eventually tripping out the motor. Frequent cleaning was necessary to keep it in operation and it was finally decided to use hand sampling.

Because of the apparent abrasiveness and the large amount of baling wire, it was thought that mill and exhauster maintenance would be higher for coke than for coal. This was not true as 3½ mo. operation showed a lower maintenance not only on mills and exhausters but on induced draft fans as well. There is a possibility that water wall block maintenance will be increased with coke because the small amount of ash leaves little or no protective slag coating on the blocks.

Increased fineness was necessary to give maximum efficiency and better performance. The usual 68 to 78 per cent through 200 mesh for coal had to be increased to 85 per cent for coke. Among other things this increased fineness cut the combustible in the ash from 70 to 15 to 20 per cent. To get this fineness in the ball mills 4000 lb. of balls were added to each mill increasing the auxiliary power required about 4 kw. hr. per t. of coke pulverized. Actual power for a given steam output was decreased, however, because of the higher heating value of the coke which requires only about 75 per cent coke for a given output. The low moisture content made it necessary to keep the cold air damper partially open to keep the air and coal mixture within the allowable limit.

This increased fineness also aided in lighting off and in sustaining combustion at light loads. Readjustment of secondary air dampers and creation of greater turbulence was found necessary to attain correct fuel distribution across the furnace and avoid continuous puffing and minor explosions. Correcting the distribution also eliminated secondary combustion.

Combustible in the fly ash is higher than for coal and even with the coke pulverized to 85 per cent through 200 mesh the combustible ran from 20 to 28 per cent as compared to 3 to 7 per cent. Actual loss in B.t.u. per pound of coke burned is slightly higher than for coal but because of the small ash content only about 50 per cent of the full power was necessary on the precipitators to give satisfactory dust separation.

Coke increases the maximum output of the boilers about 30 per cent but the unit cannot be operated at such low loads. With coal satisfactory operation can be obtained as low as 90,000 lb. of steam per hr. but this lower limit is raised to 175,000 lb. per hr. with coke. This is due to the increased B.t.u. content of the coke and the difficulty in obtaining an intimate mixture of the dust and air.

Fixed carbon per pound of coke is 76 per cent as compared to 43 per cent in the coal so that coke of same fineness as coal takes longer time for complete combustion. This difference in time has to be made up in increased fineness and better mixing if excessive carbon loss in ash is to be avoided. High carbon in fly ash interferes with precipitator operation causing intermittent arcing which resulted in very low precipitator efficiency. Properly pulverized coke with proper air and fuel distribution in the furnace gives a short and clear flame.

There is little slag deposit on boiler tubes and the superheater, economizer and air heater tubes show little dust when the boiler unit comes down for repairs. No soot blowing or slag lancing has been necessary while burning coke. Slag was tapped once a week. Absence of slag deposit on boiler tubes results in lower gas temperature entering superheater thus giving lower superheat temperature. The flue gas temperature is also lower since the unit has less fly ash deposits throughout. This, together with no slag lancing, once a week slag tapping, and low moisture content, are the reasons for getting the higher boiler efficiency of 87.92 per cent, for coke as compared to 84.5 per cent for coal, as shown by boiler tests.

AT THE Century of Progress exposition in Chicago this year, General Electric Co. will have as a feature its House of Magic, showing a spectacular section of the research laboratory in Schenectady, with an auditorium for lectures and demonstrations of the wonders of electrical science. F. H. Gale, manager of exhibits, states that the exhibit will be the largest of any one manufacturer, occupying 9000 sq. ft. in the Electricity building. The House of Magic will show applications of electricity to transportation by land and water, to industrial purposes and to home use, including cooking, refrigeration and air conditioning. Decorative backgrounding including pillars 13 ft. diam. rising 71 ft. to a black ceiling and spectacular lighting in modern style will be used to emphasize the progress in 1933 over conditions in 1893.

THE PHOTOELECTRIC cell is now being used to record continuously the amount of smoke discharged from a stack; similarly are detected variations in alternating current frequency which would cause variations of a fraction of a second in electric clocks.—The Chemical Digest.

POWER PLANT ENGINEERING February 1933

Designing Settings for Small Boilers

Wall Expansion, Facility of Repair and Baffle Construction. By J. P. Greenwood*

RECENTLY it became necessary to reset a water-tube boiler and, after search for information as to a specific method, which unearthed but little of assistance, the setting shown in Fig. 1 was designed and used.

Foundations had to go about 4 ft. below floor level, so a concrete wall was carried up to floor level, with brick wall above that point. Since air filtering into boiler settings is hard on the fuel account, the chief thought was to prevent cracks which might permit air flowing into the furnace or combustion space.

Fire brick inner walls, adjacent to high furnace temperatures, expand considerably more than the common brick outer walls. Their greater rise tends to produce cracks in the outer walls if the two are rigidly bonded. To prevent this, yet strengthen the 8-in. outer walls, galvanized iron tie strips, 1 in. by 1/16 in. were used, of length to come within 1 in. of the surfaces. They were spaced 9 in. horizontally and set midway between the abutting courses next described.

*Consulting Engineer, Dallas, Texas.

Between outer and inner walls a 1-in. air space was provided, every seventh course of brick in one wall having alternate bricks set out so that they abutted against the other wall; but no bonding was used except the iron ties. This left the walls free to expand independently, while reinforcing each other against horizontal stresses and deformation.

Above the fire line, the outer wall thickness was increased to 13 in., dovetailing with the lining wall so as to support it and allow of reparing the lower part of the inner wall without disturbing the upper part.

Concrete Foundation and Walls

Foundations and walls up to floor level are of reinforced concrete. The foundation bed is 12 in. deep, reinforced longitudinally and crosswise with $\frac{5}{8}$-in. round rods placed 2 in. from the bottom, spaced 8 in. apart lengthwise and 2 ft. centers crosswise. Under front columns, $\frac{1}{2}$-in. rods are used spaced 8 in. centers each way and, for the columns, vertical reinforcement of six $\frac{3}{4}$-in. bars as shown, joined by $\frac{3}{8}$-in. round tie

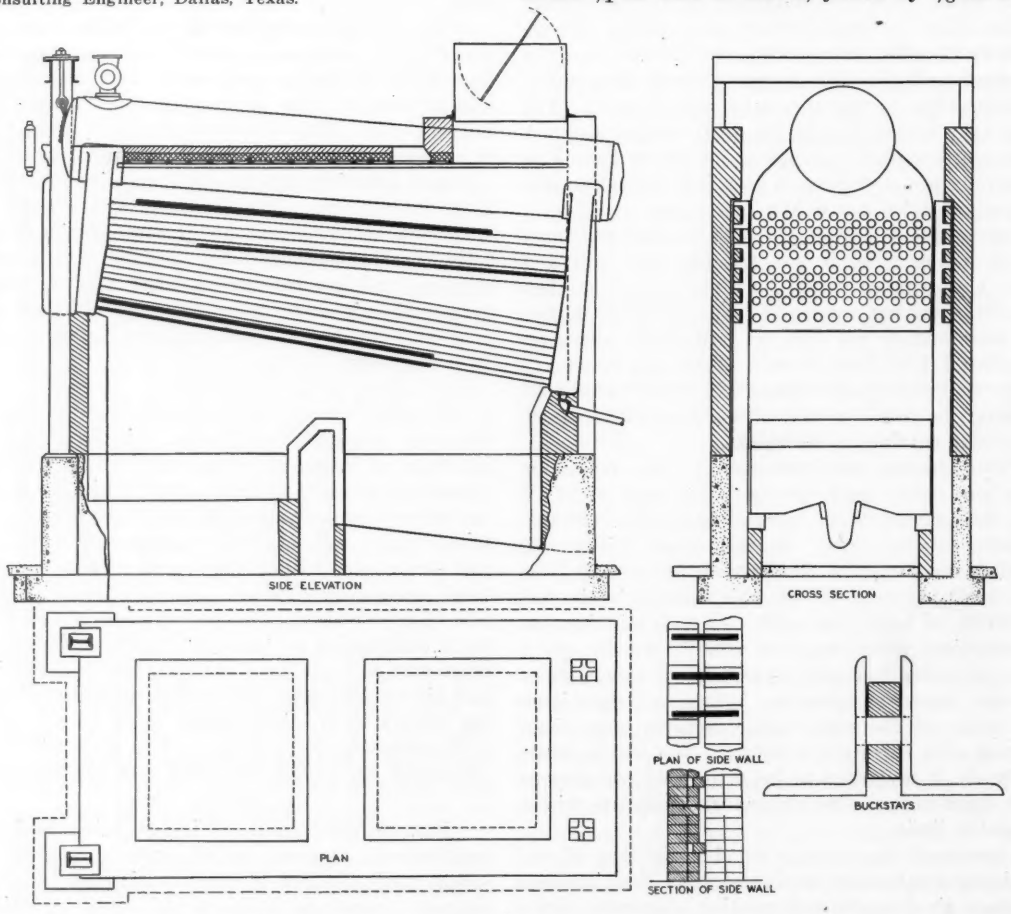


FIG. 1. SIDE AND END SECTIONS OF W. T. BOILER SETTING, PLAN OF FOUNDATION AND DETAILS OF SIDE WALL AND BUCKSTAYS

rods spaced 12 in. centers. Concrete side walls have 5/8-in. round rods, vertical and horizontal, on each side, spaced 18 in. for verticals and 24 in. for horizontals.

Expansion Spaces

At each end of the bridge wall, to be built after side walls are finished, a plank 1 in. thick was placed, to be burned out during operation, thus providing space for expansion. Also at each end of the front wall lining, a space of ½ in. was left and filled with asbestos putty.

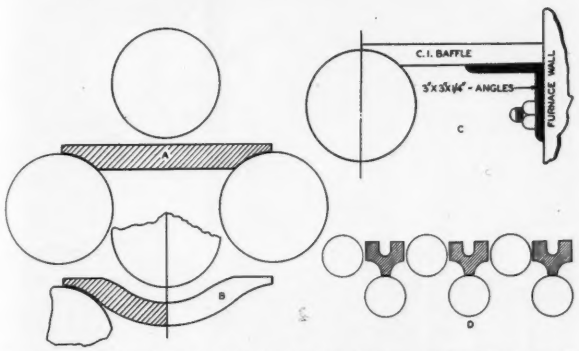


FIG. 2. DETAILS OF VARIOUS FORMS OF BAFFLES USED

For lining walls, No. 1 fire brick is best used, if coal, oil or gas is to be the fuel; No. 2 brick for wood, lignite or other light fuels. Brick are dipped in a batter of fire clay and joints rubbed together as close as possible. Outer walls are of hard-burned, pressed common brick with smooth sides and ends, laid with 3/16-in. joints of 1 to 3 cement mortar, tempered with lime to workable condition.

At the top of the walls, the 1-in. air space is plugged with asbestos rope soaked in tar or asphalt, leaving a 1-in. pipe ventilator at each end; but no ventilation at the bottom. So many criticise an 8-in. outer wall, but the writer has observed that thick outside walls are hard to keep tight, due to unequal expansion, and excess air is far more serious than mere radiation. If radiation of heat is a matter of major concern, 4½-in. insulating brick can be used between the walls and will settle the matter.

Buckstays were used at front, middle and rear of the side walls to give stability.

Baffling

Horizontal baffles were used, the lowest or furnace roof being of tile. For coal, C tile should be used to enclose the lowest bank of tubes; for gas or oil, use T tile on the second bank from the bottom.

For the second baffle, cast-iron was used, the writer advocating the form shown in Fig. 2; A for tube spacing vertically of 4 in. or more centers, B for smaller spacing. The space from outer tube to wall is spanned by construction shown at C.

Tile of the shape shown at D were used for the top baffle, a space 12 in. long being left at the front end to allow part of the gases to sweep the under side of the drum.

Buckstays were anchored to the foundation, the top ends being connected by cross rods. The stays were of two 3 by 4 by 5/16-in., 8½-lb. angles, with 1-in. cast-iron spacers between, held together by ¾-in. bolts.

Since it has been shown by Geological Survey tests that air space left in side walls is of no value in preventing radiation, just enough should be provided to allow for expansion. The construction is the same as for water-tube boilers, using tie strips and abutting spacer brick. Inner walls are vertical up to the bottom of the shell, then battered back 1½-in. on each side, to the top of the wall.

Foundations are 12 in. deep, of 1:2:4 concrete, reinforced at 2 in. from the bottom by ½-in. deformed rods set 8 in. on centers each way.

Bridge wall and end walls should have provision at the ends for expansion. The top of the air space should be closed its full length. The side walls shown are 13 in. thick with every seventh course a header course.

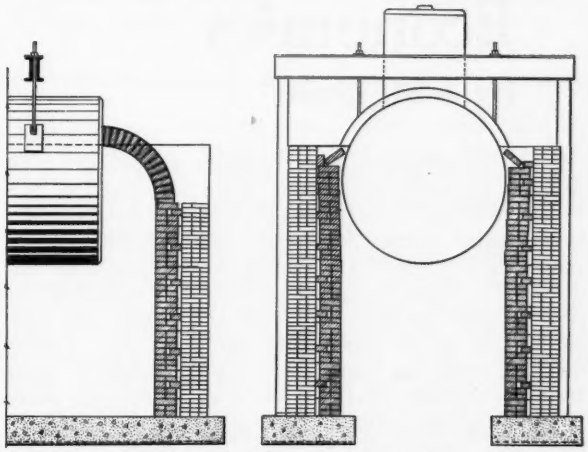


FIG. 3. SETTING FOR RETURN TUBULAR BOILER

As the writer believes that return tubular boilers should never be forced to over 150 per cent of rating, distance from grate to shell for a 72-in. diam. boiler is recommended as 48 in. for coal, 54 in. for natural gas or 60 in. for fuel oil.

With settings as shown, the life should be increased and operation will be more economical than when solid brick walls are used.

By deaerating concrete through use of a special mixing machine of Marshall Sons & Co., Ltd., Gainsborough, England, test results have been obtained by R. H. Harry Stanger on 6-in. cubes of a 4:2:1 mix, with 7 per cent water, showing as follows:

	Crushing Strength, Lb. Sq. In	
Age, Days	Normal	Deaerated
7	2774	2909
14	3314	4138
28	3149	4181
56	3341	4852

Also for the theoretically densest mix of 4.5:1.5:1 with 6.78 per cent water (using Ferrocrete) giving weight of 150 lb. per cu. ft., estimated, the average strength on three specimens was 5086 lb. per sq. in. for normal concrete and, for deaerated, on three specimens, weighing 150.5 to 151.5 lb. per cu. ft., average strength was 5924 lb. per sq. in.

Power Utilization

Variable Speed Transmission Economies

By J. M. Jewell *

ALMOST all power plant engineers are familiar with the principle of variable speed transmission, one type consisting of two pairs of cone-faced discs, double-key mounted on parallel shafts and connected by a V-shaped belt fitting the V-shaped throat formed by the discs. The discs are adjusted laterally, widening the groove formed by one set of discs and at the same time closing the groove formed by the other set. Consequently, when one shaft is driven at constant speed from a source of power, the speed of the opposite shaft is varied by the different driving diameters formed by the discs. Other types use cones, spur gears and worm gears as mechanisms.

Such variation is widely used in connection with various types of stokers, powdered coal feeders, pulverizers and fuel handling conveyors, as well as other power-driven equipment, sometimes being built in because of the many important advantages which it adds.

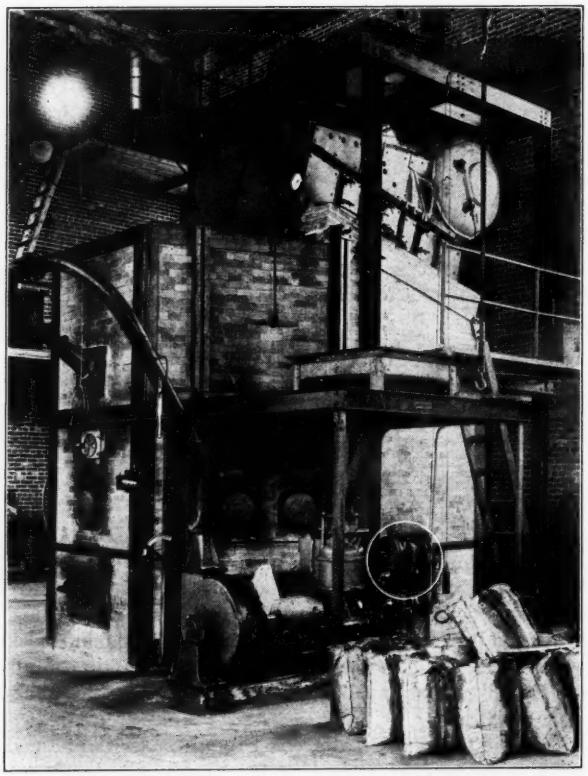
Fuel Feed Control

Installation on a mechanical stoker makes possible accurate and sensitive regulation of fuel input, one of the important elements in efficient combustion. It is possible, through such regulation, to maintain a slow burning fire, to increase it rapidly, or to reduce it to the exact degree required to insure maintenance of any desired steam pressure.

Entirely automatic stoker installations are made practicable by use of mechanical automatic design transmission, having a standard pressure regulator connected by chain or cable to the control of the transmission which drives the stoker and also regulates the draft. When the boiler pressure fluctuates either above or below the desired point, the regulator is operated to increase or to decrease the speed of the variable speed shaft of the transmission, in accordance with the requirements for fuel feed and draft to bring the boiler pressure back to the proper point.

By accurately regulating the speed of the powdered coal feeder according to the grade of coal and number of heat units contained, saving of coal consumption is effected and more efficient combustion is obtained.

On pulverizers, accurate speed control is necessary because of preparation of different grades and sizes of coal and varying demands on the entire combustion system. When, as is frequently the case, the pulverizer is combined with and made a part of the powdered coal feeder as a unit system, one transmission is used on the feeder proper and another controls the screw conveyor feeding the pulverizer.



REEVES VARIABLE-SPEED DRIVE FOR FOSTER-WHEELER PULVERIZER EQUIPMENT, BUREAU OF MINES, OTTAWA, CANADA.

Similar requirements are met on coal driers, where an automatically controlled unit is generally used, taking indication for change of speed from the weight of coal in the tower and being directly operated through a scale beam at the bottom. Different grades and sizes of coal, different temperatures and arrangement of plant also require speed control on the belt conveyor type of drier.

Fans and blowers, feed water pumps, conveyors and automatic combustion control systems are also rendered much more efficient for countless varying requirements by means of variable speed reduction, manually or automatically regulated.

Specific Applications

On a Terry steam turbine a variable speed transmission was incorporated as standard equipment, the ratio of the variable turbine shaft speed to the constant governor shaft being varied over a 6 to 1 range, adjusted instantly for any predetermined speed. The variable

*Reeves Pulley Co.

speed shaft is driven by roller chain from the main drive shaft of the turbine, the constant speed shaft being extended to form direct drive for the governor.

At the Raritan Copper Works of the Anaconda Copper Mining Co., six transmissions are in 24-hr., 7-day service to give the combustion chambers of powdered coal feeders the proper amount of fuel for highest efficiency in copper smelting. A 5-hp., 1800-r.p.m., constant-speed motor is mounted on a standard motor base and is connected to the constant-speed shaft of the transmission with silent chain. The variable speed shaft of the transmission is also connected to the screw feeder by silent chain, giving speed ratio 10 to 1.

On Lopulco pulverizing coal feeders, manufactured by Combustion Engineering Corp., with automatic variable speed for maintenance of constant steam pressure, regulation of fuel feed and draft is entirely automatic, speed of the transmission being increased or decreased to regulate the rate of fuel feed and draft. A pressure regulator is connected so that, when the boiler pressure fluctuates above or below the set point, the regulator changes the transmission, returning the pressure to the desired level.

Electrical Power Transmission

Alternating-current motors of synchronous and induction types are inherently constant-speed machines. The motors will operate at nearly full speed under light load but, under heavy load, will slow down and may stall. Variable speed transmission has been found the logical means of providing adjustable driven speed with such motors. For example, if the motor at full speed and full load takes 10 kw., at half-speed it will require practically the same amount of power but about 5 kw. will be lost as heat in external resistance. Operating at half speed 4 hr. a day for 300 days a year, the kilowatt-hours lost in the rheostat will be $5 \times 4 \times 300 = 6000$. At 2 cents per kilowatt-hour, the power will cost $120 a year.

Use of a constant-speed motor with a variable-speed transmission will save a large part of this lost power; the amount of this saving will pay in 3 yr. for the cost of the proper size of transmission, assuming an efficiency of 87 per cent at mean speed. Moreover, with the transmission the speed change is not limited to narrow limits but may be varied over a 16 to 1 ratio in an infinite number of speed adjustments.

In the Paper Mill Power Plant

Discussing the uses to which the mechanical type of variable speed transmission has been put in the power plants of paper mills, Reginald Trautschold, consulting engineer, has said: "So very sensitive is the regulation and control of speed by the modern approved forms of variable speed transmission, that such devices are now quite frequently incorporated or attached as standard equipment for changing the ratio between the speed of an engine or turbine shaft and that of the functioning speed governor. Where only a few grades and weights of paper are produced, this speed control at the prime mover has quite frequently been found to suffice but, wherever a greater variety of output is called for from a machine, the more sensitive regulation secured by having the machine driven in whole or in sections through variable speed transmissions is to be preferred."

A typical example of the economies so effected is cited by Mr. Trautschold at the Holyoke, Mass., mills of the American Writing Paper Co. Here a dozen transmissions, ranging in capacity from 10 to 100 hp. have been in constant service for a number of years, making available considerable statistical data on maintenance and operating costs. Before the installation of the transmissions, the necessity for making speed changes called for a 15-min. shutdown once a day of a 48-in. paper machine producing 500 lb. an hour, entailing an annual production loss of $937.50. Installation of variable speed transmissions made possible instant and accurate speed adjustment without a minute's delay, thus saving $937 yearly. In addition, the compact design of the transmissions made possible the utilization of valuable floor space for other purposes, effecting an additional saving of approximately $63 a year.

Compressed Air for Hammers

SUMMARIZING data from fourteen plants using air for drop and forge hammer operation, the report of N.E.L.A. General Power Committee gives in publication No. 238 facts which are of interest to engineers in plants where such hammers are used.

Three types of hammer are used, the head always being raised by pressure; where fall is by gravity; where steam or air is admitted at the start of the down stroke, then cut off and works expansively; where full pressure is kept on during most of the down stroke. The last is most common and gives a quicker and harder blow.

As usual operation is intermittent for 8 to 10 hr. a day, while steam is kept on continuously, there is considerable standby condensation in pipes and cylinders, also hammers must be operated idly between jobs to prevent accumulation of water in cylinders. With air, there is no condensation, no warming up is required, less lubrication is necessary, no condensation drips on dies to cause firecracking, wear and scoring of cylinder and piston from condensation are reduced, packing and stuffing wear longer, steam lines from boiler room to hammers are eliminated, plant power factor may be improved and cost of operation is generally lowered.

Air may be supplied by motor-driven compressors, located near the hammers, with a receiver of size to smooth out pressure fluctuations and carry over short peaks without excessive drop. Light oil or grease can be used in place of heavy cylinder oil, mixed with air in proper proportions. In some plants, sufficient oil is carried over by air from the compressor cylinder to lubricate hammer pistons but it is inadvisable to rely upon that method.

While nine of the fourteen plants reported no changes made in cylinders and valves, it is desirable to change piston rings to a flexible composition, drilling 3/16-in. holes through the piston head to the ring grooves so that air can force the rings out against the cylinder walls, to decrease air leakage which cuts down efficiency. If cylinders are badly worn, they should be rebored and possibly new pistons fitted, allowing some 0.025 in. difference in diameters for a 12-in. cylinder and in proportion for other sizes.

Valves should be refitted to reduce air leakage and to prevent floating of the hammer, by reducing oscillations after air is shut off. This involves reboring the valve cages, shrinking bands onto the piston valves of a

size to give clearance of only a few thousandths of an inch or equipping valves with piston rings, also increasing the lap on all four edges of the valves by increasing the lengths of the bands shrunk onto the valve heads, this latter to reduce floating. Special oil injectors are desirable to replace the forced feed system to cylinders and guides should be oiled separately.

Analysis to determine the advisability of replacing steam by compressed air should consider the amount of air needed, size of compressors, power to drive them and investment required to make the change. Overhead and operating expense should be less than the annual saving by use of air, if economy is to be effected.

Air pressures of 90 to 100 lb. can replace steam of 100 to 125 lb. Air needed for any hammer may be taken from Fig. 1, which has been developed by a large central station from data of actual experience. Load factor is the ratio of working time to time the hammer is under steam but the 100 per cent curve should be used for hammers that will be operating at periods of maximum

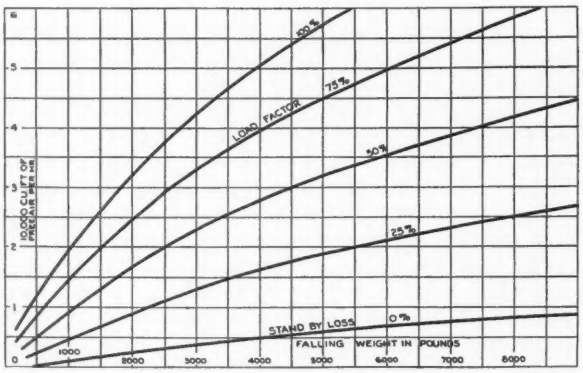


FIG. 1. AIR NEEDED FOR HAMMER OPERATION

load. Maximum demand will be the sum of demands of all hammers working at the busiest time, but may be reduced by diversifying the times of operation.

Two-stage compressor with intercooler and aftercooler is desirable, to remove moisture from the air, 1 gal. of water being required to cool 100 cu. ft. of air.

Receiver capacity near the hammers may be provided by a large air header or by a separate tank. For 22 hammers ranging from 600 to 8000 lb. in weight, at the Ingersoll-Rand plant, with 120 lb. pressure, a header 36 in. diam. by 290 ft. long is used. For a 7-hammer plant, 800 to 8000 lb. with 100 lb. pressure at Hinderliter Tool Co., a tank 6 ft. diam. by 24 ft. long is used as a receiver.

Power requirements can be taken from compressed air tables, or kilowatts per cubic foot of free air per minute may be figured as 0.151 for maximum load and 0.157 for average load. Kilowatt-hours can be found from the hourly air rate for each hammer from Fig. 1 and the daily or monthly hours of operation.

Cost of the change over should include compressors, foundations, wiring, piping, motors and control, receivers, and all installation expenses, as well as any alterations to hammers. Against present cost of operation by steam, including steam and power costs and maintenance, should be set fixed charges on new investment, power cost and maintenance estimated for air operation. The difference is the estimated saving. Items to be included may be:

Item	$ Per Mo. Present Steam	$ Per Mo. Proposed Air
Coal		
Water		
Labor		
Boiler Maintenance		
(If used for hammers only)		
Oil, Waste and Supplies		
Labor		
Elec. Power		
Repairs and Maintenance		
Hammers		
Compressors		
Piping		
Fixed Charges		
New Plan		
Amortization		
Discarded Equipment		
Totals		

Data from the plants reporting may be summarized as follows:

McClintic-Marshall Construction Co., Pottstown, Pa.
1—1000-lb. hammer; air from plant system; air cost 4½c per 1000 cu. ft.; maintenance $125 a year.

Fayette R. Plumb, Philadelphia, Pa.
4—800-lb., 2—1000-lb., 2—1250-lb., 1—1500-lb. hammers; air supply, 3460 cu. ft. per min.

Verona Tool Wks. Co., Verona, Pa.
2—4600-lb., 1—1500-lb. drop hammers; 2—2600-lb., 2—1000-lb. forge hammers; air at 100 lb. from 350-hp. synchronous-motor-driven 2195-cu. ft. per min. compressor; operating cost $35 a day.

Industrial Brownhoist Corp., Bay City, Mich.
1—1100-lb., 1—1500-lb., 2—2000-lb. hammers; air at 125 lb. from general system, receivers 5000 cu. ft.; air used 16 cu. ft. free air per min. per 100 lb. of hammer weight.

Pittsburgh Railways Co., Pittsburgh, Pa.
1—1400-lb., 1—450-lb. hammers; air at 100 lb. from general system; two receivers, each 3 ft. diam. by 16 ft. high.

Spang & Co., Butler, Pa.
1—500-lb., 3—1200-lb., 3—1500-lb., 3—2000-lb., 1—4000-lb., 1—5000-lb., 1—6000-lb., 1—1200-lb. hammers; air from five 16 by 10 by 14 in. compressors at 160 r.p.m.

Aetna Standard Eng'g Co., Elwood City, Pa.
1—2000-lb., 1—750-lb. hammers; air at 100 lb. replaced steam at 110 lb.; 750-cu. ft. compressor for hammers and air tools in shop.

Hinderliter Tool Co., Tulsa, Okla.
1—8000-lb., 1—3400-lb., 1—2000-lb., 2—1500-lb., 1—1100-lb., 1—800-lb. hammers; air supply 2—14 and 22 by 16-in. duplex compressors, 1330 cu. ft. free air per min. at 100 lb., driven by 270-hp. synchronous motors.

Ingersoll-Rand Co., Phillipsburg, N. J.
1—8000-lb., 1—5000-lb., 1—4000-lb., 5—2500-lb., 6—1500-lb., 3—1000-lb. drop hammers; 1—2500-lb., 1—2000-lb., 1—1500-lb., 1—1100-lb. forge hammers; air from general supply at 120 lb. with forge shop compressor which can be isolated; steam operation cost, $45,000 a year; air operation cost, $30,000 a year.

Air Conditioning for Comfort and Economy

FIRST AND OPERATING COSTS DETERMINE THE PRACTICABILITY OF A CONDITIONING SYSTEM. IF IT CAN'T PAY DIVIDENDS IT IS A LIABILITY. BY M. G. HARBULA*

CONSIDERATION of a cooling plant by an owner of any type of establishment should be a serious matter because this cooling plant when purchased increases the overhead and operating costs. Obviously, both must be low, otherwise regular profits of the business must be used to offset them, leaving the owner where he was before the plant was purchased.

Since first cost often determines whether or not a cooling plant will be installed, every means tending to reduce it should be exhausted by the designer. Existing equipment offers perhaps the largest possibilities. Mechanical equipment is usually built for long life and many years of cooling plant service can be obtained from existing fans, motors, air washers, coils, refrigerating equipment, pumps, piping, ducts and insulation. The owner's engineer can quickly determine capacities of such equipment also its condition and probable life. Many dollars can be saved by placing it in order and adapting it for use in the new cooling plant.

A cooling plant should be part of a proper and efficient ventilating system which will circulate large volumes of outdoor air when that air is at the correct temperature for introduction into the space cooled. Outside air in spring and fall and many days in summer is quite often at the proper delivery temperature, provided the plant is designed for it. Operating savings as high as 30 per cent may be effected by providing for this outside air in cooling plant design.

Ventilating systems for spaces not to be cooled but adjoining such cooled spaces should be co-ordinated and balanced with the air conditioning plant. The air discharged to outdoors by each exhaust fan must be supplied from somewhere and if separate supply systems are not provided such air must come from the air conditioning system and this requires additional refrigeration capacity. A certain amount of outside air must be admitted through the cooling system to freshen the air, the quantity depending upon the amount of air being positively exhausted, that required to prevent air from leaking through doors and other permanent openings and, perhaps more important, that required to keep down odors.

THREE METHODS AVAILABLE

Three general methods of cooling are available. Two employ the unit conditioner and the other a central station fan system. One unit system uses the floor or wall type unit, or both. Both consist of a radiator through which a cold substance, either ice water or a refrigerant is circulated, and a fan for circulating the air. The refrigerating machines or water cooling equipment are usually installed outside the cooling space. The other unit system employs a central station combination fan cooler and filter unit with or without distributing ducts. Being in one unit and built only in certain sizes, its use is limited since the air delivery cannot be varied without noise or loss of efficiency, as the amount of air, its delivery, temperature and refrigeration required differ on every job. Such a standard unit is decidedly an advantage, however, from a first cost standpoint if its characteristics meet the requirements of the particular job.

The third method of cooling is the central station fan system. One of its major advantages is that the ventilation, cooling and heating of the establishment for all seasons of the year can be combined in one system. The proper type and size fan can be selected as well as heating surface, filter, cooler and controls. Standard manufactured equipment can be used throughout; it is obtainable on definite specifications at low cost for all of it is highly competitive. Inherent in such a system is the provision for supplying all outdoor air for cooling on favorable spring, fall or summer days, thus eliminating the use of refrigeration and effecting large operating savings.

All the elements of equipment constituting the system can be so selected and designed as to fit practically any space available almost regardless of cubical dimensions of such spaces. The adoption of this method permits the use of all or some of the old fans, motors, heaters, pipe, ducts and refrigerating equipment usually found in all existing establishments, whereas hardly any of it could be used with the unit system. With a central fan system a proper air distributing and collecting system can be designed to fit a particular establishment, thus assuring that the air is uniformly distributed to occupants without drafts.

COST IS DETERMINING FACTOR

In choosing between units and a central fan plant, particular attention should be paid to each item entering into first cost. In an existing building this includes foundations and sometimes excavating; cutting and patching holes for equipment, ducts and piping; wiring for motors and new lights; piping for all equipment; city water and sewer connections for condensers and water carrying equipment; grilles and other plaster work and painting and decorating where existing finish has been disturbed. The cost of this work which is rarely included in cooling plant bids sometimes amounts to 25 and 40 per cent more than the cooling plant itself and it varies with each type of system proposed. The respective first costs of each with the attendant alteration expense must be analyzed separately to arrive at the lowest overall cost and if the cooling element takes up revenue space suitable rental should be included.

Most important of the decisions a cooling plant purchaser must make is the choice of one of the four or five means of cooling air. These are mechanical refrigeration, ice, steam-vacuum, absorption and well water. The choice of any of these cooling agents is governed entirely by cost, both first and operating, since exactly the same ultimate results can be had with any one. Operating cost data must be reliable and unbiased,

*Consulting air conditioning engineer, Glen Ellyn, Ill. Abstracted from a paper presented before the 23rd annual convention of the N. A. P. R. E.

based upon records of preceding jobs, not just a salesman's estimate of what they might be. All operating costs should include fixed charges consisting of interest on investment on the first cost of plant, depreciation for period allowed in tax deductions or term of lease, repairs and maintenance as of the fifth year, and operator's salary.

In comparing a mechanical plant, operating costs should show actual electric and water meter readings on compressor and pump motors as well as actual demand and energy charges. If a cooling tower is used, pump power consumption should be added. With these, one should have a record of the total number of occupants accommodated while the cooling plant is in operation, the outside and inside temperatures should be known as well as the number of hours the plant operated during the season. Other charges are for refrigerant and lubricating oils.

If steam is proposed, the pressure and consumption should be known, also condenser water costs as indicated by meter readings. With ice, monthly ice bills and water pumping costs should be added to fixed charges for total operating costs and well water cooling plant operating costs include water pumping.

Mechanical plants entail the purchase, installation and maintenance of compressors, motors, condensers, evaporators, piping, wiring and foundations. The advantage is the production of cooling effect independently in a complete plant. However, first costs are higher than any other type of cooling plant. Operating costs include operators' salary in some localities. The space required for the plant is sometimes a real problem. Local ordinances governing refrigerating plants in occupied places makes this problem more acute for only certain spaces meet code requirements. City permits should be secured before signing contracts and if these are not issued, then plans of the plant should be approved by proper authorities.

Two compressors should be installed for any cooling plant over 5 t. capacity. Each should produce 50 per cent of the total capacity required. In larger plants three or more should be included. It is a mistake also to install a plant made up of too many small machines. For instance, if a plant required 30 t. and the largest machine offered by a manufacturer is 3 t., there is no economy in first or operating cost in purchasing ten 3 t. machines. Sometimes space conditions make this necessary but as a rule a number of small machines operate less efficiently than two or three large units. With two machines it will be found that only one is required about 75 per cent of the time. Plant capacities are calculated for average maximum weather conditions and full occupancy; this condition rarely prevails but when it does the total amount is needed. By the same token, it is wasteful to operate a one-machine plant on mild days or even hot days when occupancy is light. The additional cost of two machines, each with one-half the total capacity required, may be returned in operating savings in less than two seasons.

Another type of mechanical plant uses a machine less than the total capacity required, the balance being available in the form of storage as cold water or part ice in a storage tank. One advantage is lower electrical demand charges due to the smaller motor. If off-peak power rates are available, further economies may be effected by operating on storage during such periods. Such a plant will prove less in first cost if efficiently designed and will compare favorably with ice.

The steam-vacuum method of refrigeration is being used in some establishments. Such equipment is marketed today as a competitive article, purchase of which can be made on definite engineering specifications. Steam at high pressures and water at comparatively low temperatures and low cost must be available else it will not compare favorably with mechanical plants or ice. A steam plant will cost less than a mechanical plant but operating costs could quickly offset the difference. A few points to bear in mind are these: 100 per cent more steam is required at 30 lb. pressure than at 85 lb. If the water for condensing purposes is 70 deg., 40 per cent more is required with 30 lb. steam than with steam at 85 lb. pressure. Further, if the condenser water is 85 deg. instead of 70 deg., 135 per cent more water is used. A very careful unbiased compilation of unit costs should be made before comparing steam with mechanical or ice plants for cooling. While steam plants can be automatically started and stopped, no method has been devised to automatically regulate their refrigeration output and if operating economies are sought multiple equipment is required.

Use of Ice

Ice is proving to be a most economical cooling agent in some cooling plant applications. It is used in any form, block or broken and is obtainable as low as $2.75 per ton in some localities while $4 to $6 is charged in others. A plant using ice can be made most flexible if properly designed. Ice consumption can be regulated quite closely to load demands. It can be purchased and delivered as required, depending upon the weather and number of occupants. The capacity of such a plant is limited only to the number of times the storage chamber is iced.

Since, however, the first cost of an ice air cooling plant is less than any other, it is easy because of the psychology of low first cost to make a mistake in the choice of ice as the cooling agent against any other. Some factors affecting its choice which should be duly considered are: Size of the establishment, geographical location, operating hours, first cost, length of lease and cost of ice. The cooling cost per operating hour should be definitely known.

Some general guides to determine whether ice should be used will be noted as follows: If an establishment carries on its business the larger part of 24 hours in one day, ice can be eliminated as too expensive from an operating standpoint regardless of first cost unless the owner's lease has less than a year or two to run. If a place required under 10 or even 15 t. of refrigeration per day, ice will have a hard time competing with a mechanical or steam plant, if the cost of ice is over $4 per ton. Generally speaking, ice is on a comparative basis with other cooling agents in jobs requiring fairly large tonnages and where operating hours are comparatively low.

Well water is the least expensive of any cooling agent and if a cooling project is in a territory where such water is obtainable in sufficient quantities and proper temperature, nothing else can compete. Care must be used in the design of equipment for the use of water above 45 deg. temperature, otherwise poor results will follow.

Lubrication as a Means of Cost Reduction

A Fruitful Field for Operating and Power Costs Is Found in the Essential Service of Lubrication. By Reginald Trautschold.

LUBRICATION is one of those essential services that often affords opportunities of improvement by effecting reductions in power and operating expenses. As a rule, possibilities are present of saving considerable money and almost invariably worthwhile economies can be realized. This, because lubrication entails complex and baffling operating problems, if the tolls exacted by journal and bearing friction are to be kept within reasonable bounds.

It is true the function of a lubricant is simple enough, being to separate bearing surfaces that move one upon the other and to confine as far as possible such friction as is unavoidable to molecular disturbances within the body of the lubricant, but the successful consummation of these definite requirements is far from being an easy task. The lubricant, in order to function effectively, should possess a number of distinct properties, quite irrespective of the service for which it is used. These are: body, or viscosity, sufficient to prevent the contact of bearing surfaces; as much fluidity as is consistent with its body; freedom from corrosive acids; suitably high flash and burning points; an absence of ingredients liable to cause gumming or oxidation, tenacity and durability.

So far as commercial lubricants are concerned, these exacting demands virtually limit suitable lubricants for power plant and shop services to oils, greases and those special lubricants compounded by lubricant producers that possess the essential properties of the more familiar lubricants developed to a somewhat higher degree. The requirements that lubricants be both durable and stable tends to impose further limitations in that the suitable oils are with only a few exceptions petroleum products and the greases manufactured compounds in which mineral oil is the chief ingredient.

Some exceptions are decidedly important, however, necessitating the addition of organic (animal or vegetable) oils to a mineral oil base lubricant. These compounded lubricants are necessary, ordinarily, where wet steam conditions prevail, as in engine cylinders operating on a saturated steam supply, and whenever cylinder condensation occurs to any extent. The wet steam produces a washing effect that tends to remove any protecting lubricant film of straight mineral oil. Compounding the mineral oil by the addition of organic oil has the effect of giving the lubricant ability of forming a lather of emulsion, when the compounded product comes in contact with moisture, that serves to hold the mineral oil, or main lubricant, against the cylinder walls and resist the washing action of the wet steam. Various amounts of compound are required for different steam pressures and moisture conditions.

Service and Lubricant Both Important

In an air cylinder, where dry operating conditions are encountered, on the other hand, a straight mineral oil usually proves the better lubricant, but a mineral oil of quite different character than would prove suitable in a steam cylinder. Under the dry heat conditions of operation, a steam cylinder type of lubricant would form excessive carbon, cutting down efficieney of operation and possibly introducing a danger hazard of explosion.

Turbine oils are subjected to rapid and quite marked changes of temperature and in ordinary service the mixture of moisture and air that is created tends to promote oxidation and the formation of sludges. A light bodied, highly refined lubricant is required and in high pressure steam operation, where temperatures may nowadays exceed 700 deg. F., the flash and fire points of the lubricant may assume a good deal of importance. Still another lubrication problem is presented by the requirements in lubrication for various types of refrigerating equipment, where, incidentally, still further complications are introduced by the properties of the refrigerating reagents employed. Ball and roller bearings require special lubricants and even the teeth of modern gear assemblages make exacting calls for suitable lubricants.

To meet these many and widely differing demands and countless others occasioned by the special conditions under which the lubricant has to function, changes that may be subject to considerable variation as friction wear develops and other influences bring about modifications of one kind or another, a selection of a suitable lubricant has to be made, based upon the characteristics of the component oils that govern the essential properties of effective lubricants.

These characteristics, by which commercial lubricants are commonly classified, are: specific gravity, flash point, fire point, cold test and viscosity, five variables by which the eight or more essential properties for an effective lubricant in some particular application or service have to be appraised. Naturally, with so many variables entailed, a large number of different lubricants, so far as their effectiveness in overcoming friction losses in specific services is concerned, are obtainable, but a special lubricant for each of the numerous conditions that may pertain is, obviously, impractical. Expediency limits the classification of commercial lubricants into a relatively small number of service groups, or classes; engine oils, cylinder oils, crank case oils, turbine oils and machine oils.

These are the oil lubricants in most demand in and about the power plant and industrial plant, the selection and purchase of which are of quite general concern. In no case, it would seem, can standard specification be said to exist, especially for particular grades of lubricants in any specific service class. The lubricant has to be fitted to the service, to the existing service conditions, and these may, and usually do, vary from time to time. Probably, service records alone can indicate the respective value of the various lubricants and this means that the problem of economical lubrication remains ever present and improvements always attainable.

Admittedly, the selection of the proper grade of lubricant, be it an oil, grease or special compound, for a specific service application is an undertaking in which empirical determinations based upon service records have to be relied upon for the most part. Nevertheless, if the choice is wisely made and the lubricant is correctly applied; the right amount at all times at the right place; the savings that result are decidedly attractive. A few typical examples will serve to appraise and indicate the high value frequently placed upon lubrication economies.

In one plant, more or less trouble had been encountered with the cylinder lubrication of a twin piston valve (1500-hp.) engine running at 125 r. p. m. and directly connected to an electric generator. The lubrication supplied to the cylinders was insufficient or unsuitable, resulting eventually in a shutdown for reboring the scored cylinders, replacing the piston rings and repacking. Following this relatively costly overhauling, a change in grade of cylinder lubricant employed was made and this effectively overcame the old difficulties. The engine has now been running smoothly for several years and has grown more economical in the use of steam. The economy brought about by using the more suitable cylinder oil is credited with having contributed largely to an overall saving in mill operating costs of approximately $100 a month.

In another instance, a reduction in operating expenses of close to $4000 per year was effected by a change in method of cylinder lubricant application to two steam engine units. This saving is based on the elimination of extra labor formerly required, the average annual cost of the renewal parts needed in the past and quite a substantial decrease in consumption of lubricant.

A striking instance of improvement in lubrication practice in the industrial field has to do with the lubrication of heavy gears in a steel mill. In this case, the lubricant first used for the gear teeth was an oil recommended for the service by a prominent oil refiner, but within a few months the gear teeth showed signs of excessive wear. A heavier bodied oil was substituted, but failed to remedy the trouble and the condition rapidly became acute. Finally, a special gear compound was tried, with the happy result that the gears are now giving two or three years service per set.

That improvements in lubrication practice and service are progressive and probably never fully attained is well illustrated in another industrial application, in a paper mill where good lubrication is especially necessary. It seems that the lubrication costs averaged $0.138 per ton of paper produced at this particular mill, a charge that was considered somewhat high. A change in grade of lubricant was made, consequently, and in the second year the charge had dropped to $0.093 per ton and a year later, after continuing investigations and giving the lubrication problem the attention it well deserves, to the extremely low figure of $0.066 per ton of paper output.

Unceasing Investigation Needed

In discussing lubricants and lubrication costs in this manner, it is hoped to focus attention upon the importance of lubricant selection and application in reducing power charges and operating expenses and on the need and wisdom of unceasing investigations. The plant attaining relatively high rankings in operating efficiency and in freedom from shutdowns caused by mechanical failures needs to pay especial attention to its lubricating problems. In fact, the more satisfactory a plant's lubrication system may appear to function, the more active should be the efforts to discover still better ways and means of combating friction losses. A more suitable lubricant correctly applied always means a cost saving far in excess of any possible expense in connection with conducting the investigations.

Electric Light and Power Industry in 1932

George B. Cortelyou, President National Electric Light Association and President, Consolidated Gas Co. reports that for the year 1932 the total generation of electricity is estimated at 78,000,000,000 kw.-hr., as compared with a total generation of 85,575,000,000 kw-hr. for the previous year, a decrease of 9 per cent.

Total sales of electric current for residential purposes showed a gain of 3 per cent for 1932 as compared with 1931. Consumption of electricity for commercial lighting (retail) purposes showed a decrease of 4 per cent, current for traction purposes, a decrease of 9 per cent; and the use of industrial (wholesale) power, a decrease of 18 per cent from 1931.

Total revenues from consumers of electricity are estimated at $1,840,000,000 for 1932, a decrease of about $135,000,000, or 7 per cent from the preceding year.

A further decline of 3 per cent took place in 1932 in the average price of electricity for domestic use, or from 5.78c per kw-hr. to 5.60c. At the same time, utilization of electricity by the average domestic consumer grew by 3 per cent, or from 584 kw-hr. at the end of 1931 to 600 kw-hr. at the end of 1932. Thus, the net result was to give the consumer more service for the same amount of money. The total number of domestic customers decreased during the year by 250,000, a decrease of 1¼ per cent.

With the falling off in gross revenues, there has not been a corresponding reduction in taxes, and it is estimated that taxes for 1932 will represent 11 per cent of gross revenues as compared with 10.7 per cent in 1931.

Several long-range power projects were carried through to completion in 1932. This resulted in bringing into service nearly 1,000,000 hp. of additional generating equipment. Of this new capacity, 150,000 hp. is hydro-electric plant and 850,000 hp. is steam plant. This increase brings the total capacity in the electric light and power industry to approximately 46,400,000 hp.

Reporting on the work of the Committee on Industrial Rehabilitation, chairman A. W. Robertson states that some $71,000,000 is in sight to be spent for new equipment and plant facilities. Heading the list are Amer. Tel. and Tel Co. with program to expend $35,000,000 and Standard Oil Co. of N. J. with $20,000,000. Other large programs are: Pacific Gas & Elec. Co., $5,000,000; Bogalusa Paper Co., $1,500,000; Great Southern Lumber Co., $1,250,000; Westinghouse Elec. & Mfg. Co., $1,260,000; National Steel Co., $900,000; Allis-Chalmers Co., $200,000; Pittsburgh Plate Glass Co., $350,000; Continental Oil Co., $780,000. These are a result of the first efforts of the committee, which will continue indefinitely through sectional and local branch organizations.

The Thrustor is a comparatively new addition to the family of electrical devices useful in power plants. It is a simple, fool proof device for doing anything from opening and closing valves and operating punch presses to pulling nails out of timbers.

THRUSTOR *Applications in the* Power Plant

By
R. F. Emerson
Industrial Engineeering Dept.
General Electric Company.

AMONG the many new electrical devices developed during the past few years, the thrustor is unique in its field. The thrustor, an electric motor-actuated hydraulic operating mechanism, is a very useful device which has rapidly found a place for itself in a large number of industries. It has been used for performing many operations formerly performed by electric solenoids, air pressure, or by manual labor. These applications include punch presses, conveyors, printing presses, wire stranding machines, clamping machines, laundry presses, bottle tipping machines, spot welders, machine tools and bossing machines and many others. It has even been used to pull spikes out of timbers instead of a claw hammer in the hands of a workman and has shown an increase in the amount of work done in a given time. It has been used for such heavy work as safeguarding the handling of 33-ton steel girders used in building construction in New York City and for such delicate operations as required for giving a quick smooth stop on printing presses so as to minimize the paper breakages and thus save time.

Without question the thrustor has many potential applications in power plants since as indicated in Figs. 1, 2 and 3 it has been applied to the opening and closing of valves, such as would be used in steam power or water power plants. In the case of valve operations, the

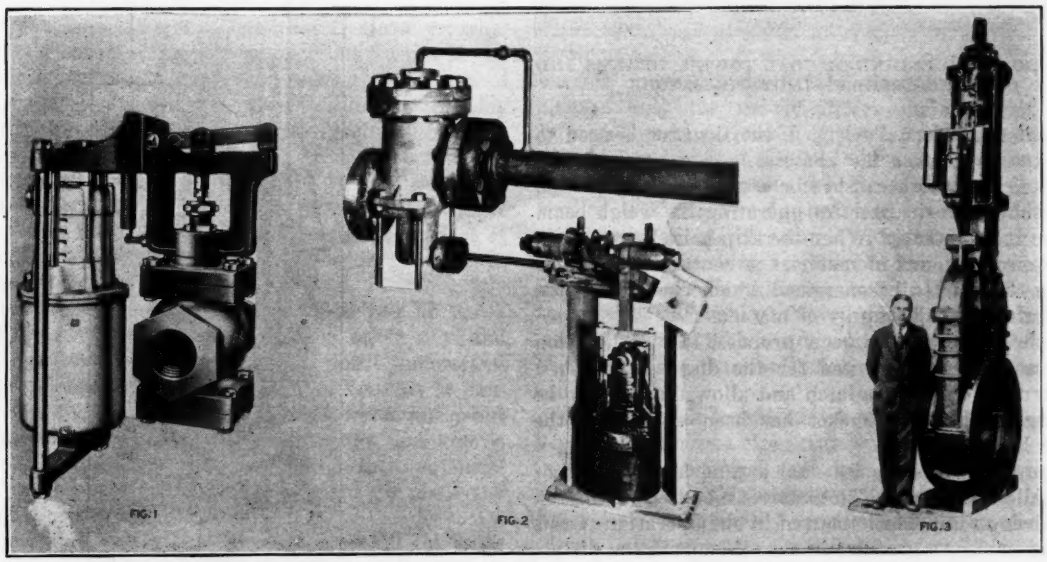


FIG. 1-3. THRUSTOR APPLICATION IN OPERATING VALVES
Fig. 1. Thrustor operated electric valve. Fig. 2. High-pressure thrustor-operated valve for removing scale from billets. Fig. 3. Water gate valve operated by thrustor.

thrustor can be arranged to either open or close the valve by remote control, and if desired can be arranged either to open or close the valve on failure of electric power. This can be accomplished by causing the thrustor to compress a spring or lift a weight when power is applied to the thrustor motor. Then on failure of electric power, the spring or the weight, as the case may be, pushes the thrustor piston back to the original position and thus opens (or closes) the valve. In the case of the hoists used for handling coal or ashes, this arrangement is used as a safety feature by causing the thrustor to compress a spring and release a brake when the motor is operating, but on failure of power, the thrustor motor stops and the spring sets the brake and keeps the load from falling.

An application of this type is shown in Fig. 4 where the thrustor is shown on the hoisting engine of a coal tower used for supplying coal to a power station.

A somewhat similar application has been made with thrustors for operating clutches and brakes on the dragline scraper used for reclaiming coal at the plant of a large public utility.

Figures 5 and 6 show thrustors as applied to a skip hoist used at a power plant where the skip hoist handles

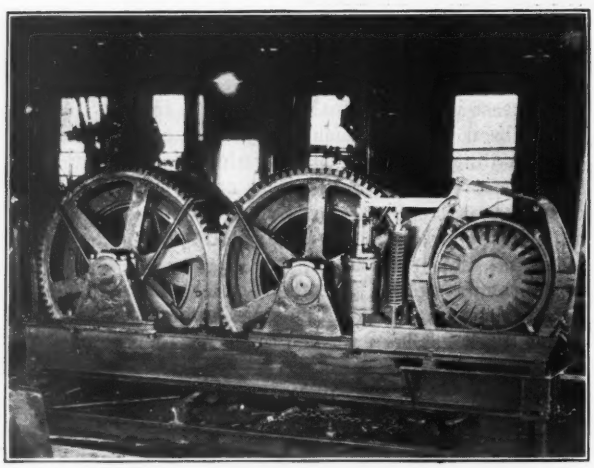


FIG. 4. HOISTING ENGINE OF COAL TOWER. BRAKES AND CLUTCHES OPERATED BY THRUSTORS

both coal and ashes. In Fig. 5, the thrustor is used to direct the spout over the ash bin or over the coal bin, depending on whether ashes or coal is to be handled. Fig. 6 shows the thrustor for operating the weigh beam latch on the skip hoist. When the skip hoist has received the required amount of material, a contact closes causing the thrustor to be energized which closes the gate, thus shutting off the supply of material.

A thrustor has also been proposed for installation on an aerial tramway used for the disposal of ashes. The thrustor will trip a latch and allow the ashes to be discharged when the bucket has been spotted in the proper location.

Figure 7 shows the internal arrangement of one of the smaller thrustors. The motor is mounted at the top and drives an impeller immersed in oil. Operation of this impeller creates a pressure in the oil beneath the piston, causing it to rise. This upward thrust of the piston produces a smooth straightline force which can be used in a variety of different ways as mentioned above.

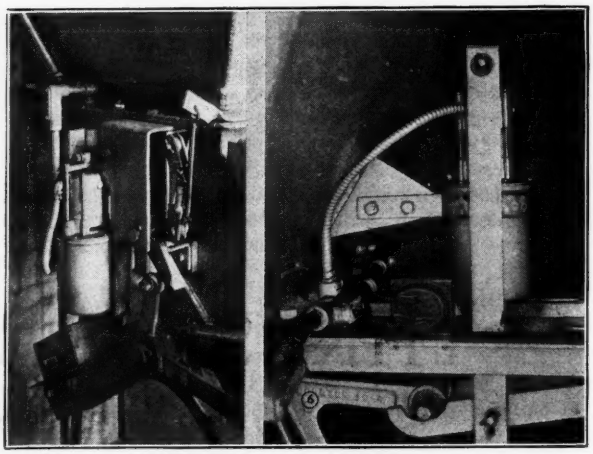


FIG. 5. THRUSTOR OPERATING SPOUT CONTROL MECHANISM ON SKIP HOIST HANDLING BOTH COAL AND ASHES
FIG. 6. THRUSTOR OPERATING WEIGH BEAM LATCH ON SKIP HOIST HANDLING BOTH COAL AND ASHES

In its operation, the thrustor does not act with the lightning rapidity of a solenoid, but rather with a smooth positive action which is highly desirable on most applications. The time of operation of most standard thrustors is usually between the limits of about ½ sec. to 2 sec. For special applications, the time periods on any given thrustor may be lengthened but not reduced by introducing special control. Thrustors have been manufactured for special applications capable of delivering a thrust of several thousand pounds. The motive power for ordinary sizes (600 lb. or less) is obtained from a fractional horsepower motor so that cost of power for operation is low.

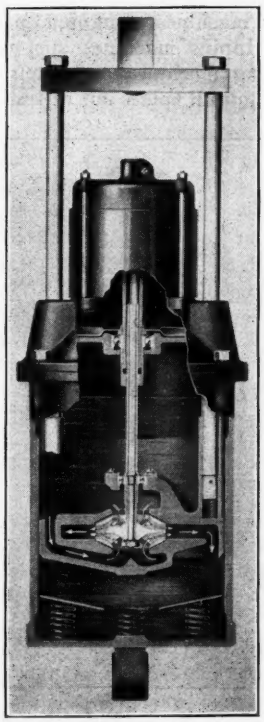


FIG. 7. INTERNAL ARRANGEMENT OF THRUSTOR SHOWING PUMP IMPELLER AND PISTON

This thing called POWER FACTOR——

Part IV. Action of a condenser in an electrical circuit. The Chief explains to Val why it is that capacity can overcome the effect of inductance.

"WELL," EXCLAIMED the chief engineer as Val sauntered leisurely into the office, "here is the reincarnation of Tom Edison himself. Where have you been? I thought you were interested in power factor?"

"I am," replied the young chemist, "but I haven't had time. By Heavens, chief, you're lucky you don't have to mess around with a gang of half-baked Ph.d's. I suppose by using force you can manage to pound a few simple ideas into the head of a coal passer but you can't into a Ph.d's intellectual dome. Say, do you know I stayed here at the plant every night this week until 12 and 1 o'clock! Wednesday night I thought I'd go home early and as I was passing through the still room I noticed the steam pressure on one of the stills was low. At first I was going to call you up but in looking around I discovered that some bright young college graduate had shut the steam off. Well, we tried to save the mess but it was of no use—we spent the whole night chopping out the resin."

"You sure do lead a heck of a life, don't you?" sympathized the chief. "But think of the fun you're having."

"Fun! Why you old fossil, maybe you think it's fun to be nursemaid to a brood of young research chemists with emphasis on the *search,* but I don't. However, what I came over here for was to tell you I had Ed put in one of those capacitors he has been talking about and it seems to have improved the power factor on that big grinder motor—I don't have near as much trouble with the fuses blowing."

"That's what I told you, didn't I?" said the chief, smiling. "By installing the condenser you introduce capacity into the circuit which neutralizes the effect of inductance. You have placed a spring in the circuit, as it were."

"That's just what I wanted to ask you about. I studied over what you explained the other day and looked over the diagrams, but I still don't understand why a condenser behaves as it does. You say a condenser acts to neutralize the effect of inductance, but just how does it do that? I can see how the kinetic energy of a flywheel is transformed into potential energy in the spring, but how does that explain the action of a condenser?"

"I intended to explain that to you," said the engineer reaching for the pad of paper and a pencil. "First, do you remember the two circuit diagrams I drew in our first discussion? I'll redraw them here (Figs. 1 and 2). In the first instance the current rose instantly to its full value, while in the second, because of inductance and the establishment of a magnetic field the

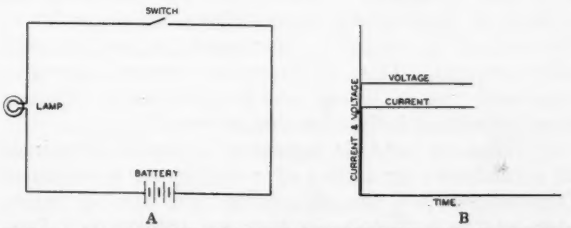


FIG. 1. (A) SIMPLE CIRCUIT CONTAINING ONLY RESISTANCE. (B) CURVE SHOWING HOW CURRENT RISES INSTANTLY TO ITS FULL VALUE IN SUCH A CIRCUIT

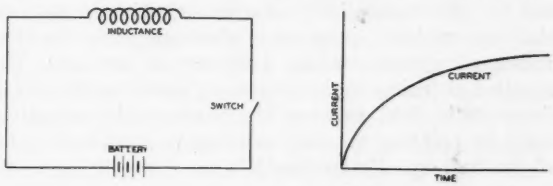


FIG. 2. (A) CIRCUIT CONTAINING INDUCTANCE. (B) CURVE SHOWING INCREASE OF CURRENT IN SUCH A CIRCUIT WHEN SWITCH IS CLOSED

current increased slowly. In these examples we considered only the use of direct current, that is the impressed voltage remained constant and once the current had maintained a steady value the effects of inductance disappeared until the current was cut off. This is similar to starting a flywheel and operating it at constant speed in one direction. In an alternating current circuit the same thing applies, but here the value of the impressed e.m.f. is changing continually, consequently, the current lags behind the impressed e.m.f. by an angular displacement which is dependent upon the inductance of the circuit. Our oscillating flywheel illustrates this condition.

"To go back to our direct current circuit, however, suppose we devise a circuit such as the one I have drawn in this diagram (Fig. 3) consisting of just a battery and a condenser. In this instance when the switch is closed full voltage is impressed across the terminals of the condenser, and current rises *instantly* to its maximum value."

"But how can current flow in such a circuit?" asked Val. "As I understand it, a condenser consists merely

of two conducting surfaces, in close proximity but with an insulating material between. How can current flow through an insulator?"

"It doesn't," replied the engineer, "but I'm glad you ask the question—it is a good one. No, current does

You can't pound ideas into a Ph.d's intellectual dome.

not flow through the dielectric of a condenser in the sense that we usually think of flow, but something like it does. A displacement current flows, which, as far as the rest of the circuit is concerned, is just like any other current. This displacement current, however, exists only for an instant and is quite small. What is more important is the charging current."

"When an e.m.f. is impressed across the terminals of a condenser by means of a battery or a generator (remember what the electrician told you—a generator acts as a pump) electrons are transformed from one of the plates to the other through the metallic circuit. Thus one of the plates becomes positively charged and the other negatively charged—that is to say, one plate accumulates an excess of electrons while the other undergoes a corresponding deficiency of electrons. This so-called charging of the condenser plates establishes an electrostatic field between the plates which manifests itself by creating an e.m.f tending to oppose the e.m.f of the battery. Understand?"

"Yes, go ahead."

"All right. Now let's see what happens in the circuit. Here, I'll draw it in the form of a curve. When the switch in Fig. 3 is first closed there is no charge on

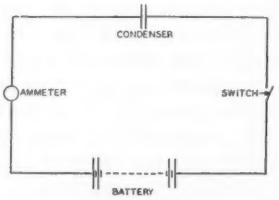


FIG. 3

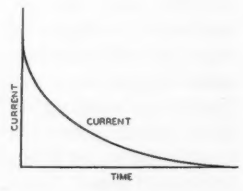


FIG. 4

FIG. 3. CIRCUIT CONTAINING A CONDENSER
FIG. 4. CURVE SHOWING HOW CURRENT DECREASES WHEN SWITCH IN FIG. 3 IS CLOSED

the plates and, therefore, no e.m.f. opposing the e.m.f. of the battery. The current, therefore, rises instantly to its full value. The instant it does so, however, a charge accumulates on the condenser plates and an e.m.f. is produced which acts to oppose the battery e.m.f. This, at first, is very small but nevertheless it reduces the effective e.m.f. slightly; as a consequence the current also decreases. Current still flows, however, and as the charge on the condenser accumulates, the counter e.m.f. of the condenser increases and since the effective or active e.m.f. (the e.m.f. causing current to flow) is the difference between the impressed e.m.f. and the counter e.m.f., the effective e.m.f. gradually decreases. Since the circuit current is due to the effective e.m.f. it is obvious that the current also decreases. Finally when the charge on the condenser reaches a value such that the potential between the plates becomes equal to the potential of the generator, the transfer of electrons from one plate to another ceases, and the effective e.m.f. becomes zero. The current, therefore, also becomes zero. Thus when the switch in Fig. 3 is closed, the current curve will take the form shown in Fig. 4. Now, does this mean anything to you?"

The engineer paused as Val studied the diagram before him and scratched his forehead with a pencil.

"Why, yes," he said hesitatingly, "it seems to be just the opposite of the curve showing the growth of current in the inductance circuit, that is, the one in Fig. 2. Isn't that right?"

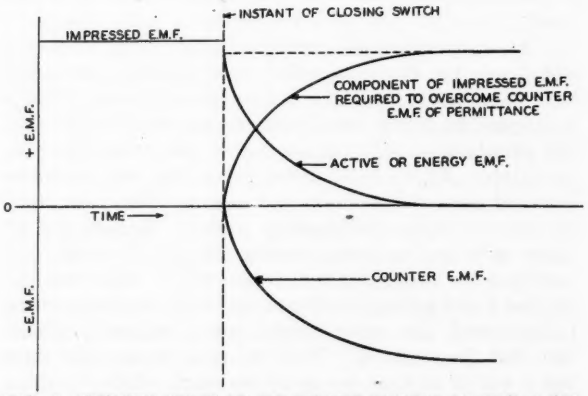


FIG. 5. CURVES SIMILAR TO THOSE SHOWN IN FIG. 4 ON PAGE 721 OF OCTOBER, 1932, ISSUE, SHOWING THE VARIOUS COMPONENTS OF THE IMPRESSED VOLTAGE IN A CIRCUIT CONTAINING A CONDENSER

"Of course it is," replied the engineer. "In the first instance, that is for the circuit containing inductance, the current rose gradually, while in this instance, it decreases gradually. In other words, a condenser has just the opposite effect upon the current that an inductance has. As a matter of fact, we can draw up a set of curves for the condenser similar to those I drew in connection with our first discussion.[1] Here, let me show you."

The chief took the pencil and after a few minutes sketched the curves shown in Fig. 5.

"These curves, you see," he explained, "show the various voltages in the circuit. At the instant the switch is closed no counter e.m.f. exists and as a consequence, the entire impressed e.m.f. is available for overcoming the resistance of the circuit. At this instant, the energy or active e.m.f. is equal to the impressed e.m.f. The instant the charge starts to accumulate on the condenser, however, the counter e.m.f. comes into existence and begins to increase. Since this counter e.m.f. acts in opposition to the impressed e.m.f. part of the latter is required to oppose this counter e.m.f. This opposing e.m.f. is called the capacity component of the impressed e.m.f. As a consequence, the active or energy e.m.f. decreases.

[1]Fig 4, page 721, October. 1932, issue.

"When the condenser is fully charged, the counter e.m.f. is equal and opposite to the impressed e.m.f. The active e.m.f. thus becomes zero and all flow of current ceases. Do you see all this?"

"Clear as a bell, professor," said Val, "keep right on going, I'll tell you when I don't understand."

"All right. Now, you recall inductance is analagous to mass. But as we have seen in the case of our flywheel, in a mechanical system, the effect of mass can be counteracted by a spring, in other words, by elasticity, so what conclusions are we to draw from this condenser action? Simply this, that capacity may be compared to elasticity in a mechanical system."

"You mean that a condenser in a circuit will counteract the effect of inductance, just as the spring in the case of the flywheel counteracts the mass of the wheel?" asked Val.

"Exactly," responded the engineer. "Suppose we connect a condenser of proper capacity into a circuit containing a certain amount of inductance in the manner shown in Fig. 6. What will happen? Well, assuming that the effects of both inductance and capacity exist independently of each other we could combine the curves of Fig. 2 and 4. Now, if we add these two curves we will obtain the steady value of current as shown in Fig. 6A. In other words, this circuit behaves largely as though it possessed only resistance. When the switch is closed, the current rises instantly to its full value."

"But doesn't it take a certain amount of time to charge the condenser?" asked the chemist.

"Yes, of course," replied the chief, "but that has nothing to do with what we are talking about. You must

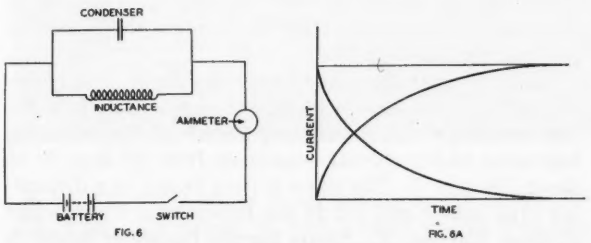


FIG. 6. THIS CIRCUIT CONTAINS BOTH INDUCTANCE AND CAPACITY

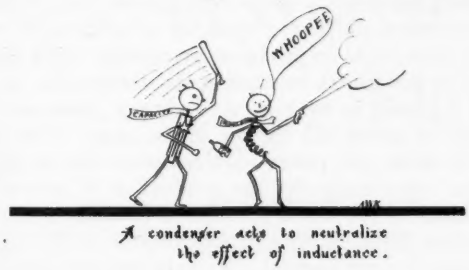
FIG. 7. (A) CURVES SHOWING HOW THE ADDITION OF THE CURVES SHOWING THE CURRENT DUE TO INDUCTANCE AND CAPACITY RESPECTIVELY PRODUCES AN EFFECT SIMILAR TO THAT OBTAINED IN A CIRCUIT HAVING ONLY RESISTANCE

remember that the current into the condenser is greatest at the *instant the switch is closed.* That is what we are interested in. At this time no current passes through the inductance because of the high counter e.m.f. induced. At the instant the switch is closed, therefore, all the current passes into the condenser.

"As the charge increases, however, the current into the condenser diminishes and at the same time the current through the inductance increases. Since this lowers the effective potential across the condenser, the current to the condenser decreases still more, and finally when the current through the inductance approaches a maximum, the condenser is fully charged.

"Now of course, when I say the condenser is fully charged, it does not mean that it is charged to the potential of the battery—that could not be. The charge on the condenser is just equal to the I R drop across the inductance. This, of course, is extremely small. Do you understand all this?"

"Yes, I think I get it but I don't quite see what all this has to do with power factor. It's all very interesting but I don't quite see where it fits in. Furthermore,



A condenser acts to neutralize the effect of inductance.

this is all concerned with direct current and power factor is only an accompaniment of alternating current. How—"

Val would have continued but the chief interrupted him.

"Yes, I know, and I am coming to that. I realize this may seem long drawn out and slow, but I want you to understand this first for it all has a bearing on the subject.

"Remember in my last discussion, I showed you how a spring in a mechanical system was able to counteract the effect of inductance? You saw that, and when I pointed out that this was analogous to power factor correction in an electrical circuit, you wanted to know why it was that a condenser could be likened to a spring. Isn't that right?"

"Yes," said Val.

"Well, all right. In this discussion I have tried to explain this to you. I have shown how the effect of inductance upon the growth of a direct current from zero can be neutralized by the effect of capacity and that a circuit containing both inductance and capacity as shown in Fig. 6 insofar as the battery current is concerned behaves exactly like a circuit containing only resistance. In other words, the condenser has an effect analogous to the spring in the mechanical system.

"Now, before I go any further I want you to think this over and then in our next discussion we'll talk about its application to alternating current circuits. Anyway. I don't want to load your frail brain up with too much of this because you have enough on your mind in trying to nurse your brood of ph.d's. Well, so long, old man, see you in the funnies."

UNDER the direction of C. S. Rankin, Power Engineer for Continenal-Diamond Fibre Co. of Bridgeport, Pa., John F. O. Stratton, acting for J. O. Ross Engineering Corp., has recently rebuilt Stratton furnaces under two Heine 435-hp. boilers at the company's plant. Originally the boilers were set in battery with two furnaces designed to operate at 200 per cent of rating. In rebuilding, the center wall was removed to a point just above the first tube rows, converting to a single unit for output of 45,000 to 50,000 lb. of steam an hr. One-half inch bituminous slack is run through a hammer mill with ¼-in. screen, then fed direct to the furnace and burned in suspension with reported average actual evaporation of 11.2 lb. of steam per lb. of coal and no noticeable discharge of fly ash from the stack.

POWER PLANT ENGINEERING February 1933

Refinery Plant Modernized

Port Arthur Plant of Gulf Refining Co. By E. B. Severs*

EXPANSION PROGRAM recently completed by the Gulf Refining Co. at its Port Arthur, Tex., Refinery involved the supply of a quantity of additional steam greater than could be produced by existing boiler plants, as well as a material increase in the demand for electric power. Steam is used in the refinery processes at a pressure of about 125 lb. per sq. in. gage. The quantities of steam and power required were such as to present an opportunity for the production of power as a by-product of the steam production process.

Boilers designed for a drum pressure of 535 lb. gage with superheaters to raise the steam temperature to 635 deg. F. were selected. The turbine is designed to operate with a throttle pressure of 525 lb. gage and 635 deg. total steam temperature and to exhaust at from 125 to 150 lb. gage. This turbine is designed to produce from 21 to 26 kw-hr. for every 1000 lb. of steam passed through it depending upon the load on the generator. The heat consumption in fuel per kw-hr. is about 4500 B.t.u.

Expected steam demands indicated that nearly 10,000 kw. could be produced and a unit of this size was purchased.

The plant is laid out for an ultimate of four boilers. Due to the tie-in with other plants on steam and electrical energy, it was considered necessary to install only three boilers at this time. When one boiler is down for cleaning or repairs, the remaining two are carried at somewhat increased output. The boilers are of 15,400 sq. ft. each, operating normally at approximately 250 per cent of rating.

Fuels Are Refinery Residuals

The fuels used at Port Arthur are the residual materials from the refining processes consisting of heavy oils and paraffin coke, for which there is no profitable market.

Paraffin coke has a heat value of about 14,000 B.t.u. per lb. as fired, is somewhat low in volatile matter and is highly abrasive.

A representative proximate analysis is as follows: Volatile matter, 11.01 per cent; fixed carbon, 88.57; ash, 0.42; moisture, 6.89.

After thorough investigation, however, it was concluded that this coke could be successfully pulverized in a ball mill and burned in this form if the air for combustion was preheated. Burning the coke in pulverized form was considered desirable, as it would permit the use of the two available fuels (oil and coke) in a single furnace, thus greatly increasing the flexibility of the firing installation. Two boilers were arranged for firing with both oil and coke and one for oil only. The boilers are of the four-drum, bent-tube type.

Furnace walls are air-cooled; the air is drawn through them and thence under the furnace bottom to the forced-draft fans, which force it through the air preheaters to the oil and coke burners.

Petroleum coke contains practically no ash, consequently no ash hoppers are provided. Such refuse as accumulates is raked by hand into a sluicing trench.

Two burners, each with its own pulverizer and exhauster serve each boiler. Each pair of pulverizers and burners has a capacity sufficient to develop 250 per cent rating on the boiler. The fuel oil system consists of the usual oil pump, heater and heat exchanger and eleven burners of the mechanical atomizing type for each boiler.

Performance of the boilers when burning pulverized coke is shown below.

Duration of test	24 hr.
Fuel per hour (as fired)	11,376 lb.
Fuel per hour (dry)	10,592 lb.
Approximate heat liberated per cubic foot of combustion space	12,900 B.t.u.
Actual water fed to boiler per hour	142,326 lb.
Equivalent evaporation to steam	131,589.68 lb.
Equivalent evaporation to blow down	1,476.66 lb.
Total equivalent evaporation	133,066.34 lb.
Per cent of rating	250.45
Refuse, per cent of fuel as fired	0.39
Efficiency of boiler, superheater, furnace and air heater	80.8

Feedwater Treatment and Heating

All of the steam from this boiler plant goes to uses of a nature that precludes the return of condensate to the boilers, hence all water for the boilers must be treated. The water available in this district contains a considerable quantity of suspended matter which is practically in colloidal form. The Gulf Refining Co. has installed a central treating plant for all boiler water at Port Arthur. The water is first given an alum treatment to coagulate the solids and then filtered and treated by the zeolite process. Secondary treatment is introduced at this boiler plant to maintain the carbonate sulphate ratio as required.

With the 100 per cent treated feedwater, it is necessary to use a continuous blowdown system, in which the heat exchanger raises the temperature of the incoming feedwater under normal conditions from 80 deg. F. to about 118 deg. F. The water is then heated in a deaerating type heater and fed to the boilers at a temperature of about 350 deg. F. Steam for the feedwater heater is taken from the turbine exhaust at about 150 lb. gage.

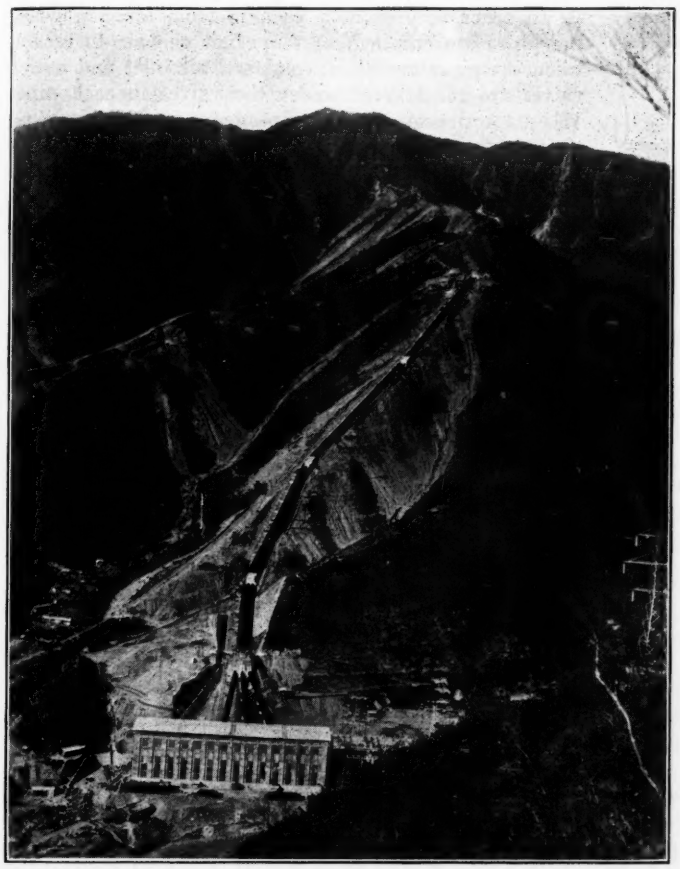
There are two main boiler feed pumps, one motor and one turbine-driven and an additional turbine-driven pump for emergency service. The latter is arranged to deliver cold water from the storage tank to the boilers in case of failure of the normal feedwater supply system. The turbine-driven pumps take steam from the high-pressure boilers and exhaust at 125 to 150 lb. into the process steam header. The two main boiler feed pumps each have a booster pump, mounted on the same bedplate and driven through the same shaft. These booster pumps receive water from the treating system and deliver it to the feedwater heater at about 165 lb. For emergency service a bypass connection around the feedwater heater is provided so that the boiler feed pump may take water directly from the booster pump suctions.

The 10,000-kw. generator feeds into a 2300-v. system on which are two other generating stations, the presence of which makes it possible to control the load on the turbine to correspond with the demand for process steam. The plant was designed and built by United Engineers & Constructors, Inc.

*United Engineers & Constructors, Inc.

World's Largest Pelton Wheels in Korea Plant

By Rene Leonhardt



AMONG THE water power developments in the far East, the largest is that known as the Fusenko Development on the Fusenko River in Korea. The Fusenko River, which is a branch of the Yao-lu River, has its source in the territory of the Fusenrei mountains, in the neighborhood of the Japanese Sea at an altitude of about 6000 ft. After flowing approximately 100 miles in a northerly direction, it joins the Oryokko River. In its upper reaches, i.e. in the Kantairi Valley, the river is dammed so as to form a reservoir. This reservoir extends over an area of 9.3 sq. mi. and has a storage capacity of approximately 25,000 million cu. ft. As a result of the storage of this quantity of water, a constant flow of 6000 g.p.s. is always available for power generation.

A pressure tunnel with a horse-shoe section, having a height of 13 ft. 4 in., a width of 12 ft. 4 in. and a length of 17 mi., leads the water to the surge chamber on the other side of the mountain range which rises from 4920 ft. to 5900 ft. In order to prevent sand and mud from penetrating into the tunnel, the entrance of the latter was located at a height of 19 ft. above the bottom of the reservoir and, furthermore, a rack is provided. From the surge chamber, a pressure pipe 10 ft. 4 in. in diameter, and made of plate ½ in. thick, leads to the power station. There the pipe divides into four branches with diameters of 1 ft. 4 in. to 3 ft. 9 in. The pipes are riveted so as to overlap at the upper part, while at the lower parts they are provided with bandages.

Two Voith regulating valves are fitted in each pipe. The upper valve can be opened or closed either by hand or by an electric motor with spur gear and worm gear whereas the second valve is designed as a quick-acting valve. The construction of these quick-acting valves is particularly interesting and for this reason it is described below more in detail. A diagrammatical representation of the operating gear in Fig. 2 shows the relation between the various component parts.

The quick-acting valves are operated by drop weights. The valve spindle supports a roller lever *a*, which is guided axially by a cross-piece *b*. This cross-piece is connected to a servo-motor piston *c*. A cup with the drop weights *d*, which close the valve, is suspended to this piston. The servo-motor, the oil pressure of which is produced by a hand pump, brings the valve into the open position and as soon as the valve is fully opened it is mechanically locked (*e*). The operating gear is so designed that the valve can be closed by a release device in the event of the pipe bursting, through the intermediary of a lifting magnet with push button release, and also by hand.

If the speed of the water in the pipe exceeds a predetermined limit, the water pressure on a plate *f* becomes so great that the latter is driven out of its normal position of equilibrium. As a result the weight lever is released. A rod connected to it, releases the catch of a second lever which, up to then, prevented by means of a stop the fall of the weight and the closing of the valve. At the same time the pilot valve is freed from an additional weight through the intermediary of rods and opens through the action of the spring. The oil in the cylinder of the servo-motor is able to escape and permits the displacement of the piston of the servo-motor. When the drop action is nearly at an end, a guide arm *h*, which is fitted on the rod of the servo-motor piston, comes and rests against the end stop of the valve. As a result the pilot valve closes partly and

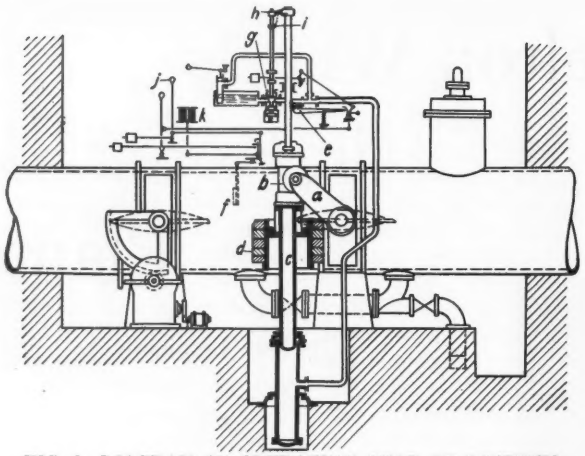


FIG. 2. DIAGRAM OF OPERATING GEAR OF FUSENKO HYDRAULIC TURBINES

the remainder of the oil in the servo-motor cylinder, which only flows out at a very slow speed, ensures that the valve comes gently to rest against its seat.

If it is desired to open the valve again, the operating gear is locked once more by means of a lever and the drop weight is raised by the servo-motor with the hand pump. Pilot lamps on the switchboard in the power station show whether the valve is open or closed. The gear can also be released by a hand lever or by a lifting magnet *k*. The mode of operation is otherwise the same.

Special supervisory gear makes it possible to ascertain quickly and easily, even during service, whether the valve is ready for operation, without disturbing considerably the flow of water.

A gas pipe is screwed into the end stop of the pilot valve *g*, and runs through the guide arm of the servo-motor piston rod. A slot is milled in the upper part of the pipe and serves to take a key *i*. If the valve is to be tested, this key is inserted into the groove of the pipe. If the drop-weight is then released, the guide arm, after a short drop, hits the key in the operating spindle and closes the pilot valve. Once the test is completed, the key is removed and the drop weight is raised again.

In order to prevent a vacuum from forming when the pipes are emptied, or to permit the air to escape when the pipes are filled, combined air inlet and outlet valves are constructed under the valves in each pipe. When the pressure in the pipe drops to 39.4 in. W.G. the valve opens and remains open until the water raises the float, i.e. until the pipe is sufficiently full again. The pressure of the water then keeps it closed.

In order to close the pressure pipe, a sluice valve, having an inner diameter of 3 ft. and a length of 5 ft. 11 in. with hydraulic operating gear is fitted in front of each turbine.

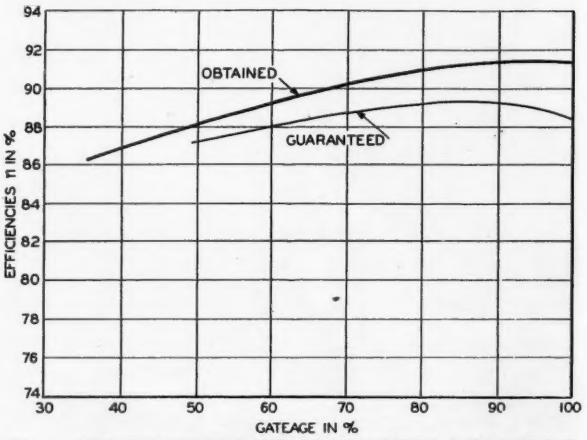


FIG. 4. EFFICIENCY CURVES, GUARANTEED AND ACTUAL

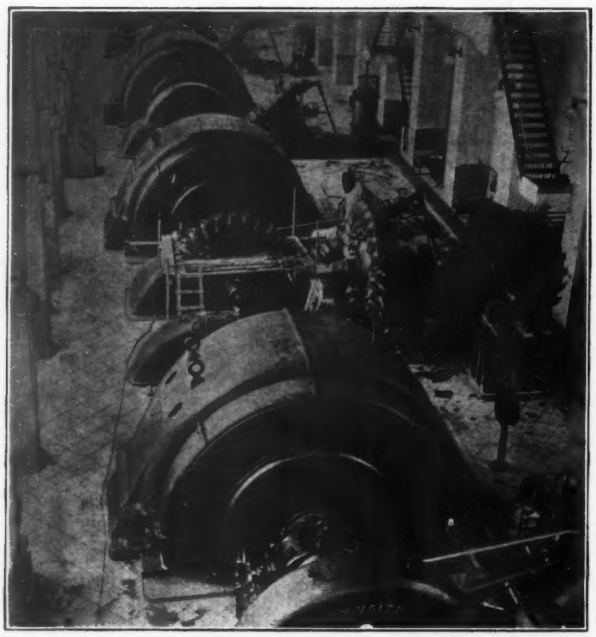


FIG. 3. THE INTERIOR OF THE FUSENKO PLANT

The Power Station occupies a floor-space of 2550 sq. yd. The four single wheel Pelton turbines with two nozzles, supplied by Messrs. J. M. Voith of Heidenheim a.d. Brenz (Wurttemberg, Germany) work under an effective head of 2180 ft. and develop 50,000 hp. with 1280 g.p.s. and at 360 r.p.m. Figure 3 is a view of the engine room.

During the official tests carried out by the Government prior to taking over the plant, a maximum efficiency of almost 92 per cent was obtained, and this result must be regarded as extremely satisfactory. The efficiency curve is shown in Fig. 4; it will be seen from this curve that the values guaranteed were not only attained, but exceeded throughout.

Figure 5 is a sectional elevation of one of the turbines. The rotor of cast steel is fitted with 13 double buckets and has an external diameter of 11 ft. 4¼ in. The buckets are fixed in relation to each other by keys and screwed on to the wheel. The total weight of a rotor is about 11.5 tons.

The shaft of the turbine has a maximum diameter of 21.6 in. The turbine and the generator are rigidly coupled together.

The nozzle frame carries the lower nozzle, including sand protection pipe, jet deflector and brake nozzle. The nozzles themselves are made of cast steel and have interchangeable end pieces. The diameter of the jet is 7 in.

Each turbine is equipped with a double governor of the Voith type, which both regulates the size of jet by means of the spear and acts upon the jet deflector. The

mode of operation of such a double governor is described below.

In the base of the governor there is a servo-motor cylinder in which two pistons move; one of these acts on the spear and the other on the jet deflector. Each piston is operated by its own pilot valve. In case of a small alteration in load, the spear works alone, and as a result of its displacement in the nozzle ensures the necessary section of jet corresponding to the load. On the other hand, in the case of a sudden drop in load, the deflectors also come into play. They deflect first part of the jet, or the whole jet, from the buckets. The spears move slowly forward, so that any dangerous increase in pressure in the pipe is effectively prevented, and at the same time the deflectors withdraw from the jet.

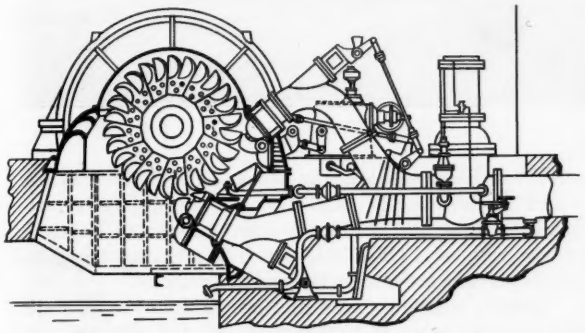


FIG. 5. SECTIONS THROUGH ONE OF THE FUSENKO PELTON WHEELS

The double governor is equipped with a protective device in case of breakage of the belt. A roller fitted at the end of a lever runs on the belt of the governor. When the belt breaks, the roller drops. As a result, the lever releases a catch. A spring actuates the governor valve and the deflector is driven forwards.

On the other hand, in order to permit of the rapid closing down of the turbine, provision is made for a brake nozzle (counter nozzle). The mouth of this nozzle has an opening of 1.7 in. The water for the brake nozzle is obtained from a pipe connected in front of the main sluice valve, which is closed off by special valves. The size of the turbine may be gauged from the fact that the uppermost point of the casing is 8 ft. 11 in. above floor level, while the lower nozzle is situated 11 ft. 6 in. below the floor. The length of a turbine unit is nearly 39 ft. In view of their dimensions and their output of 50,000 hp. per unit, the Fusenko turbines are among the most powerful Pelton turbines in the world.

Flue Gas Dust

THIS varies greatly as to amount and composition with plant conditions and fuel used. Obviously, reducing ash content in the fuel will reduce dust, regardless of how the fuel is burned.

For stoker firing, the dust will contain 15 to 35 per cent carbon; for pulverized coal, 5 to 15 per cent carbon. Also, size of dust particles will depend on the method of burning, the finer particles being more difficult to remove from the gas.

Stoker gases usually have not over 1 gr. of dust per cubic foot while pulverized fuel gases will often have as much as 4 gr.

Firing	Percent Dust Through Screen Screen Mesh per Inch		
	40	100	200
Stokered	83.12	51.16	26.01
Pulv. Fuel	99.48	90.63	65.63
Combustible in Pulv. Fuel Dust	50.13	26.41	6.84

As to removal of flue gas dust, Engineering of London, Eng. gives data from a paper by J. Mayer before the Institute of Fuel as follows:

Requirements for a satisfactory dust removal process are that it handle a wide range of concentrations and sizes of particles effectively, its efficiency increasing with the load; also that it absorb a minimum of power either for direct operation or as loss of draft in the stack. No single type as yet seems to meet all requirements but a combination of two types has given a satisfactory solution of the problem.

Test of the effectiveness of action may be considered: As the percentage of dust in the gases that is removed by the collector; objections are that use of Pitot tubes in dust-laden gases is difficult, especially when a wet filter is employed, so that samples may not be representative. A second test is to collect the dust from the gases over a long period; accuracy can be increased by length of the test and by cleaning boilers thoroughly before starting the test. Tests on models are unsatisfactory because of the difficulty of simulating actual dust sizes to scale, hence experiment must be made with full-size installations in actual service.

As to methods of removal, gravity settling is impracticable because at average gas velocity of 40 ft. per sec. and with temperature 300 deg., only particles which would be caught by 20-mesh screen will be separated out. Even at 4 ft. per sec., particles under 200-mesh size were retained in the gas after 300 ft. travel.

Bag filters result in too great draft loss, and the bag material deteriorates rapidly under action of high temperature and acid in the gases.

With electrostatic precipitation at 6 ft. gas velocity, energy consumption was 1 kw-hr. for 100,000 cu. ft. of gas but efficiency decreased as load increased.

Centrifugal collectors gave increase of efficiency as load increased but draft loss was high due to high gas velocity and efficiency was in proportion to the size of particles. Such collectors are sometimes installed in groups so that they can be connected in series or parallel, according to the load, to reduce draft loss to a minimum.

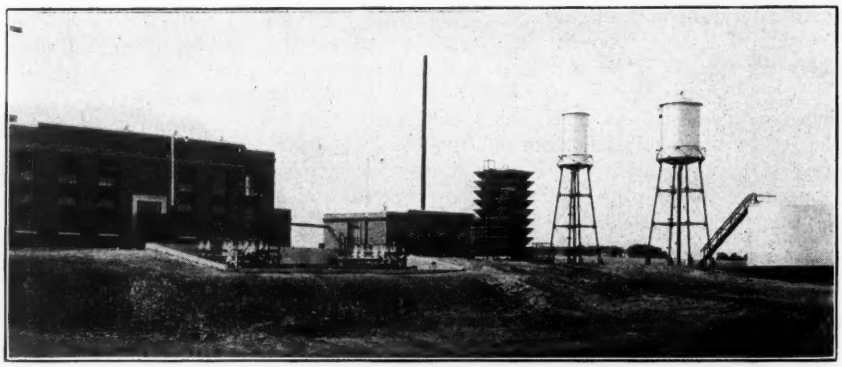
Washing systems in England are of two types, the first with hollow baffles in staggered rows, having water flowing down the outer faces; the second has gases passing through a water mist which rapidly cools them to the dew point, the dew carrying dust particles with it as it is deposited on flat plates, whence it is washed by high-pressure jets. Also gases pass through rows of staggered V baffles whose faces are continuously washed. Estimate was made that, for a boiler using 25,000 lb. of coal an hour, primary sprays will need 150 lb. and secondary sprays 1950 lb. of water a minute. This is some 2.4 gal. per 1000 cu. ft. of gas, draft loss being 1 in. of water gage.

Suggestion was made that centrifugal collectors, followed by a washing system might work well and that locating these ahead of the induced draft fan would reduce abrasion, also power used to drive the fan.

POWER PLANT ENGINEERING February 1933

Great Lakes Pipe Line Powered by Diesels

From 25,000 to 28,000 Bbl. of Gasoline Daily Can Be Handled by this 1500 Mi. Pipe Line. In Some 20 Stations Twice as Many Winton Engines Driving Prescott Pumps Handle Gasoline at 800 Lb. Pressure.



PIPE LINES ushered in a new transportation era and the new 1500 mi. gasoline line of the Great Lakes Pipe Line Co. is the latest and most interesting development of this type. The company was organized in 1930 by six of the large oil companies primarily to transport their gasoline output to the Great Lakes area. Like the railroads, the line is a common carrier and accepts for transportation at a fixed toll any gasoline offered at its terminal. As shown by the map, Fig. 1, the line runs from Oklahoma north to Kansas City, Omaha, Minneapolis and Chicago and is made up of three sizes, 4, 6 and 8 in., with capacities of 4200, 13,000 and 25,000 bbl. per day respectively.

As a result of early studies of centrifugal pumps, plunger pumps, purchased power and Diesel power, the design incorporated Diesel engines direct connected through herringbone reducing gears to reciprocating plunger pumps and with surge tanks covered by pontoon floating roofs. Arrangement of equipment and appurtenances together with the design of buildings of all three sizes of stations are identical, stations varying only in building size and engine sizes to suit the pumping capacity of the station.

Because of the need for delivering a product identical with that received, it is necessary that the actual movements of different specifications be closely followed by the chief dispatcher who keeps in touch with all stations by means of telephone and teletype circuits. The chief dispatcher knows within a few hundred feet or less where each product is located and by means of charts and maps traces its movement at all times. He controls all pumping speeds and designates tankage and movements throughout the system.

Typical Movement

A movement of gasoline from Muskogee to Chicago takes almost 20 days, a typical movement being as follows: Assume receipt of 50,000 bbl. of "X" gasoline at Muskogee for delivery to Chicago. The Muskogee station will deliver to Okmulgee through a 4-in. line at the rate of 4200 bbl. per day and the front end of this produce will arrive in Okmulgee in 14.3 hr. Due to the difference in pumping capacities between Okmulgee and Muskogee stations, namely, 4200 and 13,000 bbl. per day, it will be necessary to store some of the gasoline, which in this case is 162.3 hr. of pumping. After this has been done, the product is started north to Barnsdall at the rate of 13,000 bbl. per day and the front end of the stream arrives in Barnsdall in 24 hr.

Here it is again stored and accumulated to overcome the capacity ratio of 13,000 to 25,000 bbl. per day, or a wait of 30.6 hr. if necessary. Pumping is then started north at the rate of 25,000 bbl. per day through the 8-in. line and the progress of the batch is noted every hour. It passes Kansas City in 67 hr. after leaving Barnsdall and reaches Des Moines in 128 hr. At Des Moines reverse capacity of 25,000 to 13,000 bbl. per day is encountered and while it is possible to start the movement east immediately, for the purposes of checking pumpings and determining an over and short on this movement, the first 15,000 bbl. are stored in tankage after which the stream is switched and pumping is started to the east from the first tank at the rate of 13,000 bbl. per day. It reaches Chicago in 109.4 hr., or a total time interval of 473.6 hr. from Muskogee.

All during this time interval, dispatchers have full control of movement. Just ahead of this movement and after this movement, other products from different receiving points are handled in the system by means of storage accumulation at the different stations, they waiting their turn in the line. It is quite possible to synchronize receipts and deliveries through the use of storage tanks and variable speed pumping to a point where continuous twenty-four hour pumping takes place and the load factor of the line can be extremely high. Terminal facilities and Ethyl blending plants are provided at Kansas City, Omaha, Des Moines, Chicago and Minneapolis. At these points gasoline can be loaded into tank cars for rail shipment to their destination.

Gasoline has the same flow characteristics as water in new pipe and pressure losses were based on a pressure loss of 3 lb. per 1000 ft. of pipe. In all cases, capacity was figured and stations spaced on 800 lb. working pressure, with stations located within two miles of the 800 lb. point, depending on the topography of station sites available. Eight-inch line capacity is 25,000 bbl. per day; 6-in., 13,000 bbl. per day; 4-in., 4200 bbl. per day. Pipe line is entirely constructed of seamless

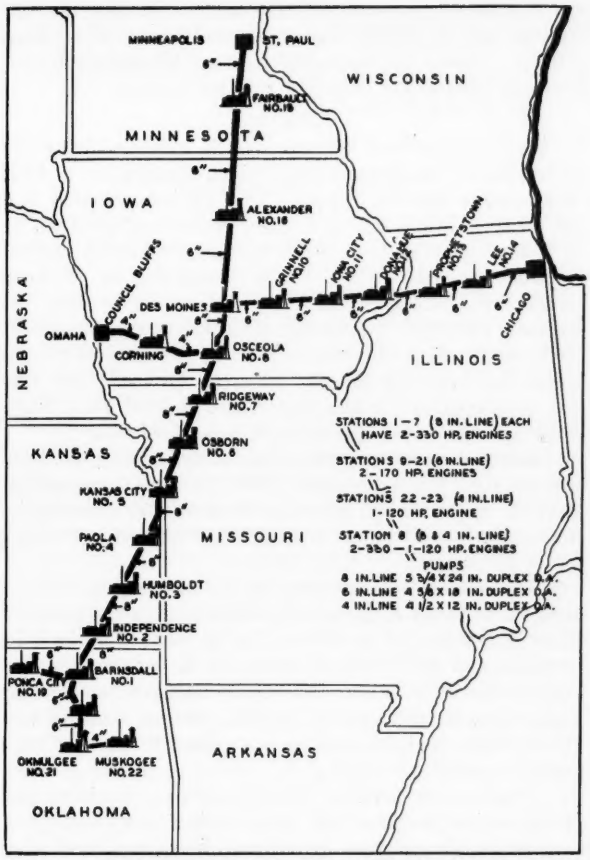


FIG. 1. MAP SHOWING LOCATION OF STATIONS, SIZE OF ENGINES, PIPE LINES AND BRANCHES

steel pipe and a factor of safety of five to six determined its weight. All joints were acetylene welded, gate valves were located a maximum of five miles apart and were bolted to high hub flanges welded in the line. A soft solid aluminum gasket was used for valves and the flanges on valves and high hubs had a raised record face. Multiple lines were used on all stream crossings of any size. Pipe line was buried a minimum depth of 30 in. and was laid to pass a pipe line scraper. Pipe protection consisted of four kinds: Simple cold coat, cold and hot coat, single wrap of tar paper and double wrap of tar paper. Hot spots determined the type of protection, but in general only a small portion of the line was coated. Conductor pipe was used under all railroads and arterial highways.

Engine sizes were chosen so as to make the station as flexible as possible and many engine parts are interchangeable between the three engine sizes. Name plate ratings are on the basis of 65 lb. M.e.p. and 720 ft. per min. piston speed. Following accepted pipe line practice no spare engine units are provided, although the engines are normally operated at from 70 to 85 per cent of their rated capacity. The governor has a speed range of from 50 to 125 per cent of normal which gives a wide range of capacities.

About 90 per cent of the load is pipe friction which decreases as the velocity drops so that at around half load every other pumping station can be by-passed to keep the working station losses at an efficient point. At normal flows a surge line floats on the pump suction to equalize flows between stations. Pumps were designed so as to increase the capacity 50 per cent by changing plunger and increasing the stroke. They are of the ball valve type with stuffing boxes with tandem glands and were built for 1000 lb. working pressure.

To insure nonturbulent flow in the suction side of the pump, connections are installed on the air chambers. This permits the fluid to be blown down to any desired level. When the line was first started, the pumps operated very unevenly. It was discovered by taking flow diagrams with an indicator on the suction side of the pump, that the pressure varied from 8.8 lb. per sq. in. abs. to 34.7 lb. per sq. in. abs., such variation occurring during one cycle. After the air chambers were sufficiently cushioned with air, the flow diagrams showed a normal pressure of 19.7 lb. abs. with slight variation.

Three sizes of stations are built depending upon the pipe line. 8-in. stations have two 330-hp., 270-r.p.m., 8-cyl., 14 by 16-in. engines; 6-in. stations have two 170-hp., 270-r.p.m., 3-cyl., 14 by 16-in. engines; the 4-in. stations one 120-hp., 250-r.p.m., 3-cyl., 12½ by 16-in. engine. These are all Winton engines driving Prescott horizontal duplex double acting pumps of three sizes; 5¾ by 24 in. on the 8-in. lines; 4⅝ by 18 in. on the 6-in. lines and 4½ by 12 on the 4-in. lines. Tabulated data regarding engines, pumps and auxiliaries in typical stations were published on page 40 of the January 1933 issue. Engines are equipped with Reed air filters, Brown pyrometers, Taylor instruments and Crosby gages.

A typical 8-in. station, as shown in the headpiece, consists of the following: One building 50 by 74 ft. made of brick and tile with precast stone coping and window sills, roof deck of steel covered with ½-in. insulating board and a built-up tar felt roofing. This building houses the engines and pumps and has a fire wall separating them. It also has attached to it an office and toilet room. One building 24 by 50 ft. constructed of brick and tile, precast stone coping and window sills, roof deck of 2-in. tongue and groove planking covered with ½-in. insulating board and built-up tar felt roofing. This building houses the heating boiler, water circulating pumps, fuel oil pumps, lubricating oil storage, water treating plant, a selection of repair parts and operating supplies.

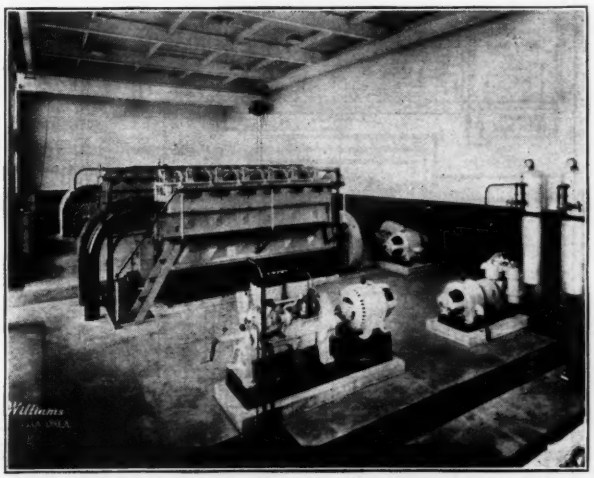


FIG. 2. TYPICAL STATION ON 8-IN. LINE SHOWING 6 CYL. ENGINES, AUXILIARIES, GENERATORS AND BUILDING CONSTRUCTION

Adjacent to the buildings is a Prichard cypress cooling tower, a concrete hotwell, a 200 bbl. elevator water tower, a 100 bbl. elevated fuel oil tank, a 1000 bbl. fuel oil storage tank, the refinery type manifold equipment and two 30,000 bbl. pontoon floating roof tanks.

Auxiliary Power

Lighting and auxiliary current is supplied by 25 kw. 125 v., 600 to 900 r.p.m., Allis Chalmers direct current generators driven from the main engine shafts by Texrope drive. These units are visible in Fig. 2. To eliminate the fire hazard, pumps and engines are installed with a 6-in. fire wall between as shown by Figure 2, the engine shaft passing through the wall, with the generator belt pulley on the engine side of the wall.

For lighting and power when the main units are down, there is installed in each station an Allis Chalmers 15 kw., 120 v. direct current generator driven by a Waukesha motor. A gasoline engine driven 11 cu. ft., 5½ by 2½ by 4 in. Ingersoll Rand compressor visible in Fig. 2 is used for starting air. A 5 t. crane is installed in engine rooms and a 2 t. crane in the pump rooms.

Gasoline coolers for jacket water were considered but due to the large transfer of heat and the low boiling point of gasoline, cooling towers were finally decided upon. Makeup cooling water is supplied from the city system, deep wells or surface reservoirs, depending upon location and is softened by a Permutit zeolite system. Cooling water is held to about 30 deg. F. maximum temperature rise with a maximum temperature of 125 F. Water from the engines drains to a hotwell where it is picked up by a motor driven centrifugal pump and discharged over the tower. A second pump picks the water up from the base of the tower and pumps it to the engine's supply line. A 10,000 gal. elevated tank floats on this line to maintain a constant 40 ft. head on the system and to supply jacket water in case of a pump failure. Three 170 g.p.m., 49 ft. head Worthington centrifugal pumps are installed for this service.

Fuel Oil

Fuel oil received by tank cars is unloaded by Fairbanks-Morse gasoline motor driven pumps to a 1000 bbl. storage tank, or delivered to a 100 bbl. elevated fuel oil tank. It is metered by Bowser meters and strained by a Wheatley strainer in the header and a Zenith Detroit strainer at each engine. No provision has as yet been made for heating or centrifuging the oil so that the cleaner gas oil is preferred, although some Bunker A is burned. Fuel oil consumption of the engines ranges from 0.39 to 0.41 lb. per b.hp. at ¾ load; the fuel oil consumption for the first 7 mo. of 1932 runs about 52.4 gal. per 1000 hp. hr. at a cost of $1.612.

Lubricating oil consumption for the same period approximated 0.935 gal. per 1000 hp. hr. at a cost of $0.428. Credit is not given in the above for the refining of used oil which shows a cost including loss in refining of $0.11 per gal.

The smaller stations vary in the size engines, pumps and surge tanks as mentioned above and in the building sizes which are 44 by 70 and 24 by 50 ft. for the 6-in. stations and 41 by 54 and 24 by 47 ft. for the 4-in. stations. Six-inch stations have three 90 g.p.m. circulating water pumps and two 17,500 bbl. pontoon floating roof tanks while the 4-in. stations have three 60 g.p.m. pumps and two 6400 bbl. tanks.

Stations are divided into two groups, receiving and intermediate stations. At all receiving stations the personnel consists of one operator-engineer and one oiler-gauger for each eight hour tour, while at the intermediate stations one operator-engineer is used for each eight hour tour.

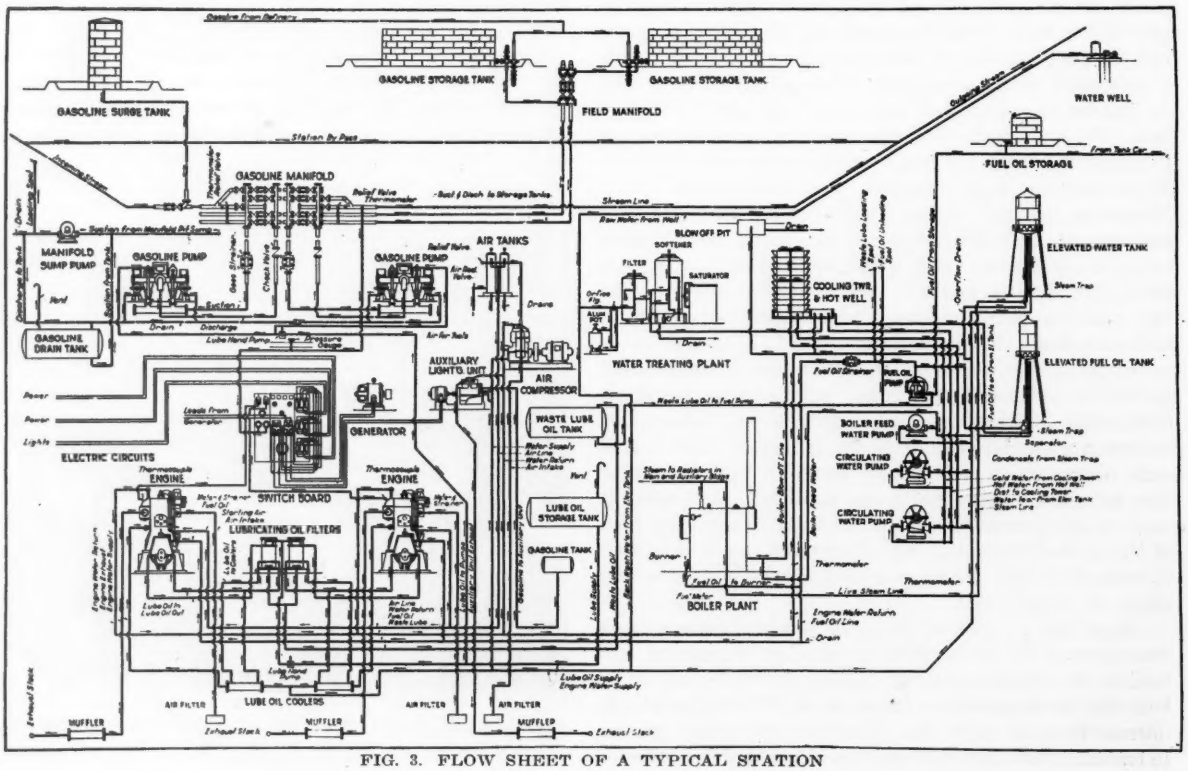


FIG. 3. FLOW SHEET OF A TYPICAL STATION

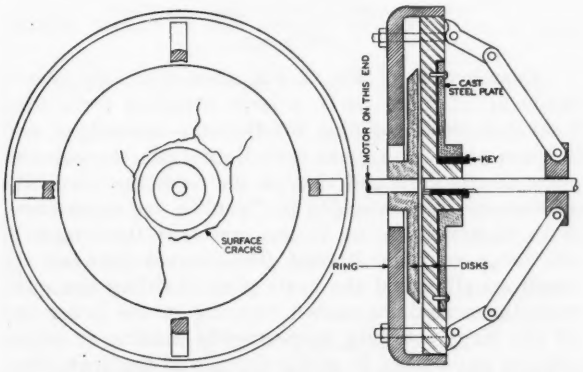
Readers' Conference

Cracked Clutch

SOMETIME AGO the clutch used to connect an 800-hp. synchronous motor to the shaft on which were the belt pulleys, developed surface cracks on the side opposite the contact face. They did not extend clear through but were deep enough so that the inspector would not let it be used. Sketch No. 1 shows where the cracks were located. Sketch No. 2 gives an idea of the construction of the clutch.

When the clutch is thrown in, the two disks, which are keyed to the shafts, are pulled together by the system of toggles, ring and bolts, the friction between the two plates causing the driven shaft to revolve. The shafting is heavy enough to carry the connected load after it is in motion but until running speed is attained the clutch is made to slip more or less because if the load is thrown on all at once, either the line fuses will blow, belt slip and burn or, as happened once, a shaft twist off. The slipping of the clutch causes heating from one side and that causes unequal expansion, resulting in cracks.

No spare clutch that size being available, the clutch was repaired by making a steel casting, boring the hub to a shrink fit size over the hub of the clutch, keying the casting to the hub and fastening it to the clutch with cap screws. This job has been in use now for 6 or 7 yr. and appears to be as good as ever. Last year a clutch of the same kind on a 200-hp. motor developed cracks and was repaired in the same way.



CRACKED CLUTCH PLATE AND SECTION SHOWING METHOD OF REPAIR

Another idea we have used to advantage is a method for locating cracks in pulley faces, spokes in flywheels or rims or anything for that matter about which there is any doubt. Some of the things we investigated and found cracked were: one spoke in a 24-ft. diameter flywheel of a 24 by 48 by 48 in. cross compound engine; 96 in. diameter by 54 in. face pulley on main line shaft of 3000 bbl. flour mill, driven by above engine.

Our practice is that if, on inspection, any hint or trace of cracks is found, the part suspected is thoroughly cleaned of all oil and grease and a coating of ground chalk applied. If a crack exists it will be plainly seen in the chalk, where oil or any other dirt in the crack will discolor the chalk. Cracks that were dangerous from an operating standpoint, but too small to be readily traced by the naked eye, will show up every time.

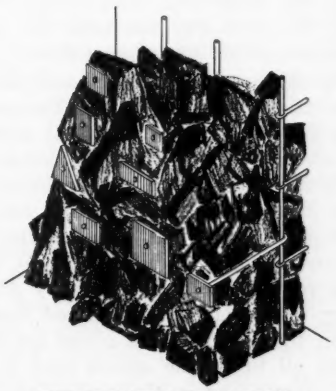
We make regular inspections every time any of our power plant machinery is down and never hesitate about using the chalk application if in doubt. In the case of the flywheel spoke, a creaking noise developed in the wheel when running. This wheel is so constructed that any spoke can be taken out. There are 10 of them and the rim is in sections, the whole thing bolted together. After all bolts were gone over and found all right for tightness, the creaking noise was still with us. Then everything suspicious was cleaned and given a coating of chalk with the result that a broken spoke was found.

Superior, Wis. FRED S. RUTLEDGE.

Boiler Room Coal Storage

AT A SMALL isolated steam plant a fireman was injured by the tumbling down of a pile of lump coal stored in the corner of the boiler room. As it was desirable to store considerable coal in the boiler room the pile had to be built up quite high and the engineer devised a scheme shown in the illustration to prevent such accidents as mentioned above.

Vertical rods shown were 12 ft. long and were held by eye-bolts run through the factory wall which were reinforced on the opposite side by steel channels. To these vertical rods, anchor pads, made of scrap pieces of plate, were attached by means of hooks of various lengths. After the coal pile had been built, the fireman washed the outside of the pile with water from a hose.



REINFORCED COAL PILE

This arrangement gave a secure storage pile conveniently located for the fireman.

Indianapolis, Ind. JAMES F. HOBART.

NOVALUX fire beacon, for use outside fire department stations or at street intersections where fire apparatus may pass is a visible and audible signal, with motor-driven siren, now being introduced by the General Electric Co.

Driving Conveyor Belt Idlers by Motors

WITH FURTHER reference to my article on page 583 of the September, 1932, issue and Mr. Emerson's comment of it on page 780 of the November issue the conveyor drive I mentioned is a method of driving used in Germany, where it has only recently been originated. It was described in one of the 1931 numbers of Progress. This is a German publication printed in the English language and deals with recent engineering advances in Germany.

As far as I know the motors used in Germany have been of special design. I have given considerable thought to this subject and have seen it applied on trial. Consider the case of a plain conveyor drive. The whole power is supplied at the head pulley and the idlers are driven by the friction of the belt and their surface speed should approximate to the surface speed of the belt. The more freely the idlers rotate the less will be the wear on the belt, so the less power which has to be delivered from the belt to rotate the idler the less the belt wear. The idea of motor driven idlers is to drive the idler at approximately the belt speed independent of the belt, and to proportion the idler motor so that it will take part of the load. If the speed of the idler falls, the belt will tend to bring it up to its speed and the motor will be driven by the belt. If the idler runs faster than the belt, the belt will act as a drag in it and tend to reduce its speed.

The load which any idler will carry will depend on its speed and the grip it makes on the belt. The grip it makes on the belt will to a great extent depend on the load and as the load on the belt increases so will the load on the idler motor. For driving idlers, direct current shunt wound motors are best. These are to a great extent self governing, their speed does not vary greatly with the load and can easily be regulated, to suit the practical conditions of operation.

Naturally the speed characteristics of all the motors used on the drive must be similar. The speed of each motor must be tested under practical working conditions; a speedometer is fixed to each idler and any speed alteration with various belt loadings noted. The shunt rheostat can be adjusted in the position where the speed is most constant. It is found, however, that under normal conditions of conveyor belt operation, the speed of a direct current motor does not vary sufficiently to warrant any special method of speed control. Small variations in the speed of the idlers are unimportant because with all idlers the speeds tend to lag behind the belt, this depending on the loading and the friction in the idler bearings. With alternating current motors speed control is more difficult, the slip being a great difficulty. Squirrel cage induction motors can be used but all the motors used on one drive must be similar in slip and speed characteristics. By care in construction and design these can be made as nearly alike as necessary, although they will not be identical. When the conveyor is working very light or on no load it is usual to disconnect the motor. This is done by means of a clutch which disconnects the motor and allows the idler to run as a plain idler.

This solves the difficulty of light load running. The motors are only connected when the load on the conveyor is above a certain minimum. As several motors are used on the one drive as load comes on the belt the additional load will be distributed over the several motors so the increase in load on any one motor will not be great. Giving to this load distribution the difficulty of slip is less than would be thought and provided the motors have similar slip and speed characteristics on a normal conveyor drive load variations do not give trouble.

Herts, England. W. E. WARNER.

Drip Pockets for Welded Pipe Lines

AN IDEAL drip pocket for application to welded steam lines must be of such a design that it can be conveniently welded to the line and be readily accessible for cleaning. Like any drip pocket it must have a convenient connection for piping to a trap and must have sufficient volume to catch mud and scale without restricting the outlet to the trap piping.

These requirements are met by the drip pocket shown in Fig. 1. It was developed following the use, on a large tunnel piping contract, of a design shown in Fig. 2. The requirements called for something that could be erected at low cost in the field and would prove satisfactory from a standpoint of maintenance. The working steam pressures varied from 40 to 150 lb. per sq. in.

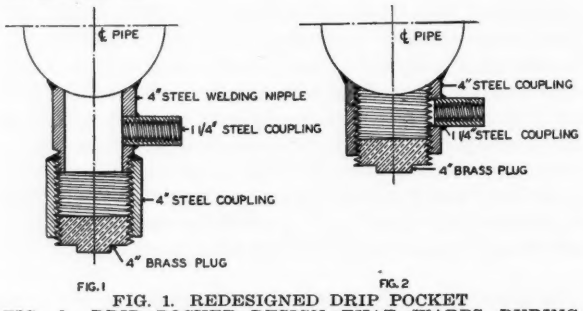


FIG. 1. REDESIGNED DRIP POCKET
FIG. 2. DRIP POCKET DESIGN THAT WARPS DURING WELDING

Examination of Fig. 2 will show that this unit is made up of three parts, a large coupling for a mud pocket, a small coupling for the trap connection, and a brass plug for a clean-out. Both from the point of view of the shop and that of the field, the simplicity of this unit recommended it. Trouble was experienced with it, however, due to the fact that the length of the large coupling limited the distance between the small coupling and the brass plug; welding the small coupling sometimes caused warping of the lower end of the large coupling, consequently making it impossible to get a tight fit at the threads of the brass plug.

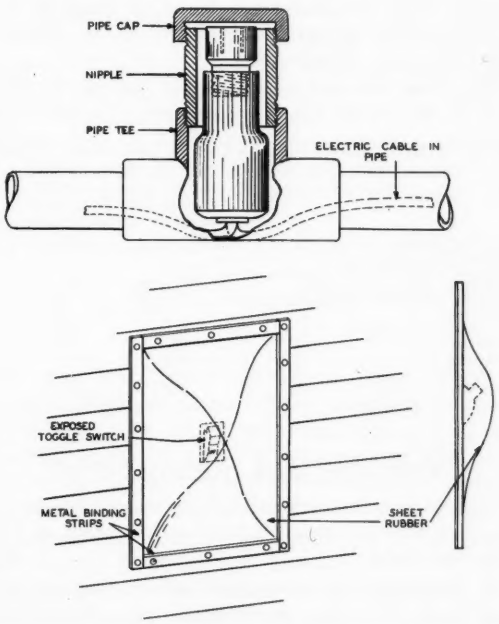
This difficulty is eliminated by the design of Fig. 1 without in any way detracting from the ease with which the unit can be erected in the field. The shop work consists of making up the threaded joint between the welding nipple and the large coupling, cutting the welding nipple to take the small coupling, welding in the small coupling, back-welding the threaded connection at the welding nipple, screwing in the brass plug and testing the entire unit. The dimensions given are applicable to drips for 6 to 12 in. pipe mains.

The total number of drip pockets required can be entirely made up in the shop so that the only field work necessary is the cutting of the pipe line and welding the unit to it.

Arlington, Mass. THERON BEAN.

Waterproofing Outside Electric Circuits

OUTSIDE ELECTRIC SWITCHES and sockets are likely to short circuit and cause trouble unless these are protected against rain or water from any source. Two improvised but effective methods of waterproofing outside electric service in an inexpensive manner are shown in the attached drawing. While these were used at an automobile service station, they are equally useful for any other location. The first of these is a socket for a prong type of connection. The electric cable is encased in pipe, terminating in either pipe tees or ells. The socket is placed inside the pipe fitting and a pipe cap covers the socket when not in use.



ARRANGEMENTS FOR WATERPROOFING CIRCUITS

In another installation is a toggle switch secured in the wall of a building. Over the toggle switch is a piece of sheet rubber. This rubber is held tight around the switch by means of a small metal frame and screws. These ideas are worth using even in closed garages, especially if a wash hose is used.

Washington, D. C. G. A. LUERS.

Motor Starters

ALL ELECTRICAL equipment should be protected against overloads because such overloads cause undue heating which eventually causes failure. Starting current for alternating-current motors thrown directly across the line is from three to five times normal full load value and fuses or thermal relays must be large enough to take care of this momentary rush of current. Ordinary fuses, if made that large, give no protection against normal overloads.

Double throw switches with two sets of fuses, starting and running, are common but if the switch is not held in the start position long enough, one of the running fuses may be burned out when the switch is thrown. This causes the motor to operate single phase and may burn out a winding. Time delay fuses or thermal cutouts are the most satisfactory as they allow a large flow of current for a short period but cut out if the overload continues.

About 25 per cent above the name plate rating is a good working average for protective devices although conditions sometimes make a higher value necessary. Circuit breakers of direct-current generators can be set at about 150 per cent, if the feeder circuits are properly protected. Alternating-current generators are commonly connected to the bus without overload protection but the feeder circuits must be taken care of by proper protection. All the fuses, thermal cutout or relays for the same machine should be set or made for the same value. Unless this is done, one circuit may open leaving the motor operating on single phase which will cause rapid heating if the lead is over about 50 per cent.

Full load current in amperes per terminal varies with the size of the motor and with the voltage; the higher the voltage the lower the current.

CURRENT PER PHASE FOR 440-VOLT A.C. MOTORS

Hp.	1-ph.	2-ph.	3-ph.
½	1.7	0.8	0.9
1	3	1.5	1.6
5	13	6.5	7.5
7.5	20	10	11
10	25	12.5	14.5
20	48	24	27.5
30	70	35	40
40	95	47	55
50	110	55	63
100		107	124
150		160	183
200		205	237

If the voltage is 220, these values should be doubled and if it is 110 they must be multiplied by 4; for 2200 volts, divide by five and for 550 volts multiply by 4/5.

Knife switches, contacts and fuse clips should be inspected frequently for burned, loosened or corroded surfaces in order that the various parts will give the protection for which they are intended.

Brooklyn, N. Y. P. F. ROGERS.

Repairing by Bronze Welding

ON PAGE 620 of the August 15 issue is an interesting article describing how a motor frame was repaired with bronze welding. We applied that process for the repairing of a cast-iron gear-wheel with excellent results. The wheel, 24 in. in diameter, used to operate a coal elevator, broke through the spokes so that the rim and hub were entirely separated. Two of the spokes were broken in two places.

In making the repair, the broken ends of the spokes were first chamfered on both sides. We placed the wheel in a fire pit, fitting the ends of the broken spokes in place, then built a coke fire around it, getting the heat distributed as evenly as possible. When heated sufficiently, the fire was removed and the welding done in the pit. Each spoke was built up at the break and the bronze welded along the spokes about 3 in. each way from the joints. Then the whole gear was covered with warm ashes and left several hours to cool before it was replaced. The job held several weeks without giving any trouble until a new gear arrived.

Matawan, N. J. GEO. B. LONGSTREET.

Plant Operation Problems

Refrigerating Machine Calculation

Q. Recently we tested our refrigerating machine and figured we were doing 22 t. refrigerating duty under the following conditions: Calcium brine circulated, 190 g.p.m.; range in temperature cooled through 3 deg. F.; specific gravity of brine, 1.21; specific heat of brine, 0.8. In these calculations we used the following formula:

$$T = W S (t^1 - t^2) \div 200$$

Where, T = refrigerating duty in t.; W = weight of brine circulated per min.; S = specific heat of brine; $(t^1 - t^2)$ = range in temperature cooled through, deg. F.

The ammonia compressor is rated at 30 t. refrigerating duty per 24 hr. at 184 lb. head pressure and 16.67 lb. back pressure. We operate at an average of 140 lb. head pressure and 10 lb. back pressure. Is the machine working at capacity? F. J. S.

A. As far as the method and formula for figuring the capacity of your machine is concerned, you are correct, but apparently your figures are not quite right. You do not mention the temperature at which the specific heat of your brine was taken. The specific heat of 1.21 sp. gr. brine varies from about 0.714 at 59 deg. F. to 0.686 at —4 deg. F. The value of 0.8 which you give is apparently a little high and your actual capacity probably lies somewhere between 19 and 20 t.

Of course a machine rated at 30 t. and 16.67 lb. back pressure could not be expected to develop 30 t. at 10 lb. suction pressure. With the head pressure lowered to 140 lb., the volumetric efficiency will be slightly higher but the big difference in capacity from standard conditions is from the density of the ammonia which at the beginning of the stroke is much less than under rated conditions.

Density of 10.3 lb. ga. pressure saturated ammonia vapor is 0.09117. At 16½ lb. suction pressure the ammonia has a density of 0.1122. Compressor capacity would, therefore, be reduced in approximately the ratio of 0.09117 to 0.1122 or to about 82 per cent; roughly to 24½ t. Your machine is, therefore, working at about 80 per cent capacity.

Action of Zeolite on Ammonia

Q. Make-up water for our boiler feed system is taken from the cooling water leaving an ammonia condenser and softened in a zeolite system. Would a leak in the condenser, leaving the water with an appreciable amount of ammonia, either affect the operation of zeolite softener or would it be carried through the softener to affect the feedwater. H. C. H.

A. If the softener influent is contaminated by ammonia through condenser leakage or other source, most of this ammonia will be removed by the zeolite in the same way calcium and magnesium is removed from the water, that is by the base exchange process.

The only effect on the operation of the softener would be that the capacity for removing hardness would be decreased by the chemically equivalent amount of ammonia removed. This is because the zeolite would be removing ammonia as well as hardness so that the number of gallons softened between regenerations would be decreased slightly.

Regarding the ability of the zeolite to remove ammonia from solution, we would point out that a modified zeolite is used for ammonia determination in urine analyses. The attached table shows an analysis of the operation in an actual plant in which the water contained 20 p.p.m. of ammonia.

The above question was answered from data supplied by E. P. Schinman, Chemical Engineer, Permutit Co.

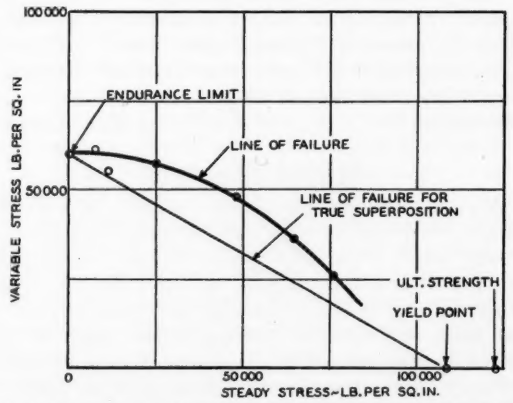
WATER ANALYSIS SHOWING REMOVAL OF AMMONIA FROM ZEOLITE. Results expressed in parts per million

	Calculated as	Filtered Raw Water	Soft Water
Total Hardness	$CaCO_3$	168	0
Calcium Hardness	"	...	0
Magnesium Hardness	"	...	0
Alkalinity (Methyl Orange)	" AlkA	97	111
Alkalinity (Phenolphthalein)	" AlkB	0	0
Causticity	" AlkC	0	0
Free Carbon Dioxide	CO_2	14	4
Chlorides	Cl	44	44
Sulphates	SO_3	...	...
Iron	Fe	...	...
Ammonia	NH_3	20	0.9

Variable and Steady Stress

If a rotational or vibrational stress is added to tensile stress, what effect does this have on the point of failure of the material? A. M.

A. Simultaneous existence of alternating and steady stress leads to various combinations of pulsating stress. Little experimental information is available but in general failure under alternating stress will occur sooner when a steady stress is added but no definite law of superposition seems to exist. The curve shows data from the Westinghouse laboratories. The line of actual failure is raised considerably over the line of true superposition between the endurance limit on one hand and the yield point on the other.



TEST RESULTS SHOWING THE EFFECT OF VARIABLE STRESSES FOR 3.5 PER CENT NICKEL STEEL.

Synchronizing with Power Companies

REFERRING TO page 831 of the December issue of Power Plant Engineering, an inquiry Synchronizing with Power Companies, signed by C. P. the following may be of interest.

We have had some considerable experience with this particular problem and the most satisfactory solution, of course, is to provide the governor mechanism of the engine with a governor control motor for adjusting the governor while in operation. In view of the fact that apparently the expense of such an equipment is not desired or warranted at the present time, the following can be done:

The governor spring can be set to some predetermined point of the engine synchronizing with the power company's lines by bringing it in "on the throttle". This is not a very satisfactory condition as a fixed out-put results unless throttling is used in addition which is, of course, wasteful of steam.

Unless the machine is equipped with a governor control motor for adjusting the governor while in operation this cannot be used as heat requirements vary unless throttle is resorted to.

Cedar Rapids, Iowa. JOHN M. DRABELLE.
Mechanical and Electrical Engr.
Iowa Electric Light & Power Co.

IN REPLY TO C. P.'s question on page 831 of the December issue of Power Plant Engineering as to whether or not it would be possible to synchronize his industrial plant with the local power company's system without going to the expense of purchasing a synchroscope, I will offer the following comments.

Synchronizing can be accomplished by means of lamps instead of the scope, and connected up so as to synchronize with the lamps either lighted or dark, as may be desired. I prefer to do it with the lamps lighted, to guard against the possibility of synchronizing with a lamp, the filament of which might just have burned out. A carbon filament lamp is the best for this purpose. The connections for this circuit are generally known and space need not be taken up here to detail them. Perhaps any of the power company men will make the hook up for you in a few moments if you have your material on hand.

You will have control of the load on your unit at all times under the conditions mentioned. However, your unit will lose some load each time the power company's units are speeded up (and the exhaust pressure on your unit will drop), and it will likewise pick up load (and increase your exhaust pressure) each time they lower their speed, unless you do the same. Thus you will find that your exhaust pressure will not remain constant with a given governor setting of your unit but that it will vary with the power company's changes of speed. This is assuming that the governor on your unit is in good order.

In connection with this you may run into something you have not as yet considered, and that is "hunting" by your unit immediately after you have synchronized with the power company system. Should this occur, the best remedy is (I have found) to pick up full load *immediately* on your unit until it settles down to smooth operation, and then drop load until you are down to that needed for your requirements. The slight pulsating of your ammeter and kw. indicator that will most likely be noticeable when things are going along smoothly will be of no consequence, if not objectionable to the power company.

Virginia, Minn. FRANK J. SCHOBER.

Reversed Circulation

I BELIEVE I have found a satisfactory solution to the problem of reversed circulation presented in the November issue. In hot water installations of the usual type, circulation is obtained by two connected columns of water of equal heights and unequal weights, seeking a common balance. By weight, of course, is meant the weight per cubic inch or the difference in the specific gravity of the two columns. This difference is caused by the fact that one column contains the tank, hence its larger volume is slower to become heated and consequently is always at a lower temperature, and a higher specific gravity than the other column, the heater discharge line.

In the hookup in question, however, the columns of greatest height are of the same volume or nearly so. So when the heater is put into operation they will be equally heated, thus remaining at the same specific gravity and no incentive for circulation is obtained. But as soon as the water in the tank has become sufficiently heated by convection and conduction, to make a temperature difference of several degrees in the water in the upper and lower parts of the tank, we will have a reason for circulation and in the following manner: It is evident that the heated water in the heater inlet and discharge lines will contact water of different temperatures at or in the line near the tank. And as water expands and contracts as it is heated and cooled the water in the heater inlet pipe will contract the more rapidly by giving up its heat faster due to the cooler water in the bottom of the tank. This of course will create an upflow in the heater inlet pipe and the heated particles of water will expand and rise at once to or near the top of the tank, displacing water at the top causing it to flow out and down the heater discharge line.

It seems as though a circulation of this kind would be very poor and inefficient, even with the circulation in the correct direction, due to the check valve.

Chicago, Ill. ROY M. STINSON.

Metals at High Temperatures

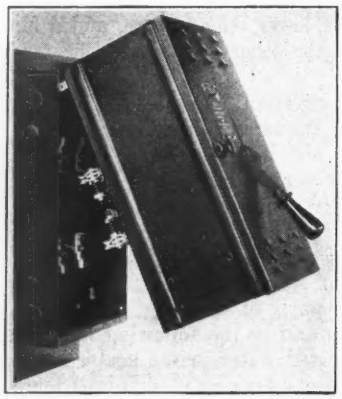
IN THE answer to the question regarding metals at high temperature, which appeared on page 784 of the November issue, the vertical scale of Fig. 1 should be tensile strength in hundreds of pounds per square in. instead of tensile strength in pounds per square inch.

AS AN indication of progress in Diesel engine design for the marine field, Busch-Sulzer engines supplied the U. S. Shipping Board in 1927, of air injection type were 6-cylinder, 30 by 52 in. at 104 r.p.m., developing 3950 hp. They were 25 ft. 3½ in. high by 40 ft. 10¾ in. long, weighed 842,000 lb. or 213 lb. per hp. and sold for $74 per horsepower. Airless injection engines are now furnished, 6-cylinder, 30 by 42 in. at 150 r.p.m., developing 4200-hp. They are 16 ft. 9½ in. high by 28 ft. 2½ in. long, weigh 485,000 lb., or 115.5 lb. per hp. and sell for $40 per horsepower.

New Equipment

New Enclosed Air Circuit Breakers

THIS LINE of manually and electrically operated, trip-free, multipole air circuit breakers for the control and protection of circuits in all fields, announced by the General Electric Co. and known as Type AB-2, are obtainable in metal-enclosed construction, with or without pull box, metal-enclosed with pull box and disconnecting devices to permit



inspection of the breaker while it is disconnected from the source, or mounted in dead-front and metal-enclosed switchboards which are shipped assembled from the factory.

Ratings range from 15 to 400 amp., 250 v. d.c. and 600 v. a.c. High interrupting capacity is attained when the breaker opens by transfer from main contacts to intermediate contacts and then to arcing horns by the rapid action of a magnetic blowout.

Two independent overcurrent tripping devices are included, a thermal inverse time trip and a magnetic trip which operates instantly on approximately ten times the normal current.

Constructed with a back-connected, base-mounted air circuit breaker enclosed in a metal box with a hinged cover provided with a breaker position-indicator and an operating handle for opening and closing the breaker, this equipment affords dead-front operation of the breaker with freedom from live parts, barriers of insulating material preventing possible arcing to metal enclosures. Ventilating louvers in the door, aided by the interior construction of the breaker, permit air circulation around the breaker parts, to assure a low temperature rise.

High-Ratio Speed Reducer

WHERE HIGHER ratios of speed transformation than 100 to 1 are required, two worm gears can be connected in series, and commonly both sets of gears have been enclosed in one housing. With the high-speed worm wheel mounted directly upon the slow-speed worm shaft, only three moving parts, except for bearings are required for transformation ratios up to about 8000 to 1.

In the new double-reduction worm gears produced by the De Laval Steam Turbine Co., Trenton, N. J., the high-speed gear wheel is

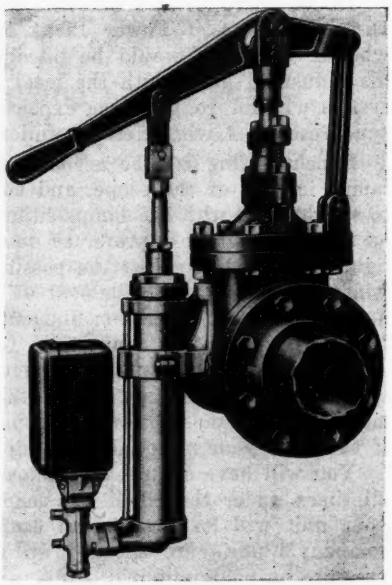
mounted upon the slow-speed worm shaft but flexibility in the arrangement of the drive has been gained by using separate housings for the high-speed and slow-speed gears, so that the unit with horizontal slow-speed shaft, for instance, can have the high-speed driving shaft extended in either or both directions, likewise the slow-speed shaft. The worm may be rotated either clockwise or counter-clockwise, facing the worm from the motor or driving position. Standard gear sets are cut with right-hand threads. For the unit with vertical slow-speed shaft, six arrangements are possible.

Lubrication is by splash system, the high-speed worm shaft, the shaft which carries the high-speed gear wheel and the slow-speed worm having ball bearings. The slow-speed shaft, which in double reduction gears may be called upon to carry considerable forces, has plain sleeve bearings, or, in units in which the slow speed shaft is horizontal, may be fitted with tapered roller bearings.

Solenoid Operated Gate Valve

TO MEET DEMAND for centralized control of steam, water and other process lines, from one point, the Ruggles-Klingemann Mfg. Co., Salem, Mass., has produced a solenoid-operated gate valve for steam pressures up to 125 lb. and water pressures up to 150 lb.

This is of the relay servo-motor type, with the small solenoid actuating the hydraulic motor, allowing for a wide variation of opening and closing speeds to suit the conditions of the installation. Adaptability is for remote control of inaccessible gate valves, for centralized control of a series of gate valves, for effecting a change over or by-pass quickly. The lever shows the position of the valve and can be used for manual operation when necessary.



Slow closing of these valves allows installation in water lines without air chambers, being adjusted until no water hammer is produced. Valves are arranged to open full pipe size to allow full flow with no pressure loss, yet may be adjusted to limit motion to any opening desired. They will close against any foreign object which may become lodged in the valve, only to the extent of the power of the hydraulic motor. Stopping part way, for any reason, will not effect a burn out of the solenoid coil.

New Recorders

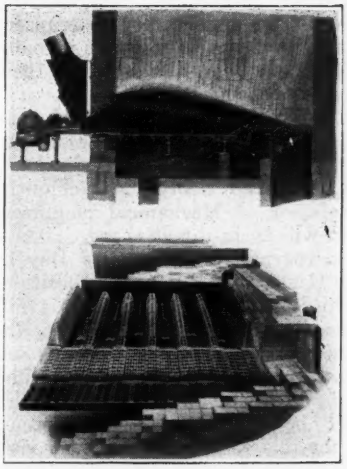
Two NEW types of Micromax Recorders are introduced by Leeds & Northrup Co. of Philadelphia, for CO_2, pressure or temperature. The round-chart junior type has a scale with large lettering over which moves an indicating hand visible across a room, with a 24-hr. chart 10⅜ in. diam., using straight line coördinates, on a strap 3½ in. wide. The 16½-in. case can be mounted flush or overhanging, mechanism being arranged to swing out of the case for inspection and maintenance. The strip recorder is now furnished with a dust-tight case, having a rubber gasket as a seal, with single handle, lock outside the gasket and switches for motor, lights and control operated external to the casing. Here, too, mechanism can be swung out of the case for accessibility.

Multiple Retort Stoker

IN THIS NEW stoker, made by Detroit Stoker Co., Detroit, Mich, an inclined fuel bed is secured by the special slope of the tuyeres. The coal is pushed in at the front and distributed through each retort beneath the fire, gases distilled by the heat of the furnace being mixed with air as they pass upward through the fire and coke burning as it rises above the tuyeres, in an incandescent zone. Retorts are of square, box-like design with depth to permit slow distillation of the gases. Reciprocating movement of the bottom plate of each retort, with its auxiliary pushers, gives uniform distribution of the fuel with a continuous breaking or slicing action on the fuel bed, movement of each retort bottom being adjustable to suit changes in type or size of the coal.

Coal is fed to the plungers from a large capacity welded steel hopper, observation doors over each retort permitting the operator to know conditions and to remove any foreign refuse. If stoppage of a plunger occurs, a shearing pin prevents any damage, only one retort being temporarily out of service. Large square plungers increase the coal feed per stroke and reduce tendency for the coal to arch or bridge over in the ram cases, while adjustable liner plates eliminate wear and insure correct fit on the plunger.

Mechanical drives, which consist of machine cut worms and gears mounted in Timken roller bearings, are fully enclosed and run in oil to operate steel cranks from which the coal plunger of each retort receives

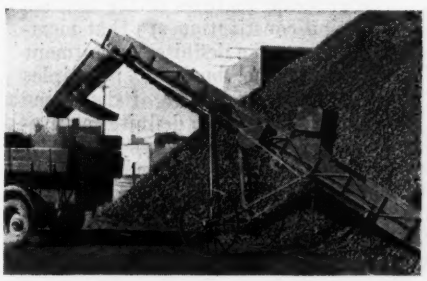


its movement. Drives, ram cases and crankshaft brackets are mounted on a box girder type frame that extends across the front of the stoker.

Air distribution is accomplished by zoning to air chambers and by admitting air against the fuel through many tuyere openings at an effective angle. Extension moving grates at the rear of the retorts permit burning of all coke in the refuse before it reaches the dumping section, whose grates are air cooled and have pockets to hold some ash as a protection to the iron work.

Light Cleated Belt Conveyor

THIS MACHINE, just announced by the Barber-Greene Co. of Aurora, Ill., is built in three lengths, 21, 25 and 31 ft. and two widths 14 and 18 in. for handling coal, coke and similar bulk materials. Simplified truck and hoist design makes it possible for the operator to adjust the discharge height of the boom, thus saving coal breakage. Other features are 12 in. welded steel truss, 7½ in. trough, divided cleats, squirrel cage return guide rollers, head end take-up, fixed rigid tail end, low foot end with detachable hopper plates, return belt protected by decking, alemite lubrication. The maximum angle of operation is 35 deg.



Electrode Holder

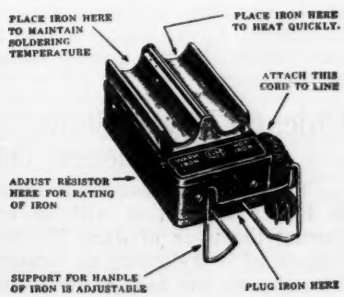
FOR ATOMIC-HYDROGEN arc-welding, General Electric Co. has developed this new type holder to carry flexible tungsten electrodes, which are stranded of small diameter wires. These electrodes are flexible, are carried in curved tubes and are brought into position by a screw-feed ejector, such that the electrode is used to a stub 1½ in. long. Before it drops from the nozzle tip, a new one has been inserted into the ejector and a few turns brings it to welding position. Consumption of electrode is not increased; waste of ends and breakage should be reduced. Hydrogen tubes are detachable from the holder handle for replacement by the user. Position of the fan-shaped welding flame may be regulated parallel or at right angles to the axis of the handle by turn of a thumb screw, for easy working in confined positions. Wearing parts are arranged for quick replacement.

Flat Cured Hose

INTRODUCTION of this fire hose to the industrial field is announced by B. F. Goodrich Co. following acceptance by municipal fire departments. It is manufactured flat, becoming round only when filled with water, making it easier to coil in small space, also giving longer life as strain is reduced on the rubber, since there is no tendency to bulge or buckle on the reel or rack.

Soldering Iron Stand

THIS STAND, made by G-M Laboratories, Inc., Chicago, Ill., has two cradles. When placed in the left hand cradle, the iron receives only sufficient voltage to keep it at the minimum yet proper soldering temperature for immediate use, with material saving of power and increased life of the heating element. When the iron is either in actual use or is placed in the right hand cradle, full line voltage is automatically applied to keep the iron up to temperature.


PLACE IRON HERE TO MAINTAIN SOLDERING TEMPERATURE
PLACE IRON HERE TO HEAT QUICKLY.
ATTACH THIS CORD TO LINE
ADJUST RESISTOR HERE FOR RATING OF IRON
SUPPORT FOR HANDLE OF IRON IS ADJUSTABLE
PLUG IRON HERE

E. M. Herr Dies

EDWIN M. HERR, vice-chairman of the Board of Directors of the Westinghouse Electric and Mfg. Co. died at his home in New York on December 24 after a long illness. He was 72 years old. Mr. Herr was also a director of the American Manufacturers Export Association; the Radio Corporation of America, the Westinghouse Airbrake Co. and many other organizations.

For many years he was a resident of Pittsburgh, where he was president of the Westinghouse Electric and Manufacturing Company, and during the 18 years of incumbency as president of the company, its annual sales increased from $20,000,-

000 to 10 times that figure. He relinquished the presidency of the company in 1929 to become vice-chairman of the board of directors. He was decorated by the Emperor of Japan in 1920.

Herr was born in Lancaster, Pa., May 3, 1860, and while young his parents moved to Denver, Colo. Before completing his high school course he was a telegraph messenger and at 16 was a telegraph operator. Later he was operator and station agent for the Kansas Pacific Railway at Deer Trail, Colo. Continuing his studies while employed, he was able to enter Sheffield Scientific School of Yale University in 1881 and was graduated in 1884.

In 1905 Mr. Herr was elected vice-president of the Westinghouse Electric and Manufacturing Company, served as one of the receivers of the company, and upon its reorganization, a year later, resumed his old position. He was made president in 1911.

Chicago Power Show and Engineers' Day

THE 6TH MIDWEST ENGINEERING & Power Exposition will be held during the week of June 25, 1933, instead of in February as formerly. The change has been made to give engineers attending "Engineering Week" an opportunity to transact business with a large group of manufacturers who will be showing their products at the Power Show.

Educational features of the Power Show will be sponsored by Armour Institute of Technology, Chicago, and George F. Gebhardt, Professor of Mechanical Engineering, will be in direct charge.

Program for Engineers' Day at the Century of Progress Exposition, according to information now available, includes an assembling of Engineers at the Fair Grounds on Wednesday, June 28. At this time a program of the day's activities will be given each one present. After this assembling period a visit to prepared scientific exhibits will begin under suitable guides and in a way to exemplify the exhibit from the engineering viewpoint.

In the evening the Engineers' Day banquet is scheduled for the Stevens Hotel. Accommodations are hoped to be available for the actual seating of 2500. With the possibility of using loud speakers, an increased assemblage of 5000 will be able to hear the addresses.

Edison Electric Institute Formed

COMPANIES comprising 85 per cent of the electric light and power industry in the United States, recently decided to junk the National Electric Light Association and to form a new organization to be known as the Edison Electric Institute. George B. Cortelyou, who has been president of the N.E.L.A., is the president of the new organization. William V. Hageñah of Chicago, vice-president of the Byllesby Engineering and Management Corporation, is vice-president. Bernard F. Weadoch is executive secretary and Edward Reynolds, Jr., treasurer. All of these officers held similar positions in the N.E.L.A.

Only utilities will be represented in the new organization with company, individual and honorary memberships. The Institute is expected to absorb both the N.E.L.A. and the Edison Association to form a single association.

Significant features of the new association constitution are that members must make definite commitment to follow the business principles laid down; the power of discipline is given the officers; definite requirements are made as to the filing of audited financial statements; individual membership must be approved by the companies with which the members are connected and power is given the officers to investigate the business practice of member companies.

The governing board of 24 includes James Simpson, chairman of Commonwealth Edison, Peoples Gas and Public Service Company of Northern Illinois; William Chamberlain, president of the United Light & Power Company, Chicago, and John J. O'Brien, president of H. M. Byllesby & Company, Chicago.

The determination of the members of the association to police the industry is seen in a paragraph of the constitution which provides that the membership committee shall have authority to "consider and investigate the business practices of any company member and to expel, suspend or take any other disciplinary action against any member guilty of a violation of proper or ethical business practices, or for failure to furnish information as required."

The company members shall from time to time and not less than annually publish financial statements, including balance sheets, showing gross and net income, operating expenses and surplus accounts, which statements shall be certified to by independent firms of certified public accountants who shall have audited the books of the company.

All statements and data furnished to consumers, stock exchanges and stockholders; all information designated for public dissemination and all reports to governmental authorities shall be accurate and clearly indicate their source.

All contracts between any member companies which involve the furnishing of management, supervisory, purchasing, construction, engineering or financing services to operating electric utility companies shall be so drawn and so operate in practice that the charges to the operating company shall be reasonable and commensurate with the value of the services rendered and the fair cost thereof to the company furnishing the services.

The institute's membership is divided into four classes: Operating company members, holding company members, individual members (officers or employes of company members) and honorary members.

Announcement of the new trade association was made at the office of the Niagara Hudson Power corporation. Utilities leaders present included B. C. Cobb, chairman of the Commonwealth and Southern company; Floyd L. Carlisle, chairman of Niagara Hudson, and George B. Cortelyou, president of the Consolidated Gas company.

News From the Field

WM. B. SCAIFE & SONS Co., Oakmont, Pa., announce the opening of a sales and engineering office for its water softeners, filters and purification equipment at 42 East Ave., Rochester, New York, under the management of F. H. Wisewell, who has been with the United States Gypsum Co., and has had extensive experience as engineer and constructor in the power and industrial plant field.

INTERNATIONAL Acetylene Assn., has elected officers as follows: E. J. Hayden, central division manager, Linde Air Products Co., Chicago, president; H. B. Pearson, Compressed Industrial Gases, Chicago, vice-president; directors, W. C. Keeley, Jr., National Carbide Corp.; W. H. Ludington, Air Reduction Sales Co.; H. S. Smith, The Prest-O-Lite Co., Inc.; C. A. McCune, Industry & Welding; W. D. Flannery, Harris Calorific Sales Co.; L. F. Loutrel, Shawinigan Products Corp.; Philip Kearney, K-G Welding and Cutting Co., all of New York; A. J. Fausek, Modern Engineering Co., St. Louis, Mo.

GOULDS PUMPS, INC., announces its acquisition of the Hydroil Corp. of Lebanon, Ind., which has manufactured oil purifying apparatus. Plant and manufacture will be transferred to Seneca Falls, N. Y., D. B. Clark and W. P. Alexander of the Hydroil Corp., joining the Goulds forces. Product will be known as Goulds Hydroil purifiers.

NELSON B. GARDEN, a graduate engineer who has in previous years been connected with H. O. Swoboda, Inc., Pittsburgh, Pa., has again joined that organization for consulting work on light and power plants and electrical heating.

STANDARD Lime and Stone Co., Baltimore, announces a new line of Capitol Rock Wool insulating products against heat and cold, Frank C. Russell, formerly with Mineral Felt Insulating Co. to be manager of the department. Two newly equipped plants at Millville, W. Va., will manufacture the raw material from rock deposits and will fabricate various finished products.

O. B. WILSON, formerly manager of the Cleveland, Ohio, office of The Brown Instrument Co., has been appointed district manager of the territory comprising Texas, Louisiana and Southern Arkansas, with headquarters at Houston, Texas.

REEVES PULLEY Co. has opened a branch office at 39 So. Clinton St., Chicago, Ill., with D. C. Batterson in charge, assisted by T. E. Fisk and C. E. Hill.

NEW DEVICES announced by Square D Co., include a Recti Filter for converting alternating to direct current, and weatherproof circuit breakers in capacities up to 50 amp., 2 and 3-pole for 125 and 250 v.

CHARLES F. MEDBURY, for the past 23 yr. manager of the Montreal office of the Canadian Westinghouse Company, died on November 2.

THE COOPER-BESSEMER CORP. of Mt. Vernon, Ohio, celebrates its centenary with the beginning in 1933. Two brothers, Charles and Elias Cooper built a small iron foundry at Mt. Vernon in 1833 and thereby laid the foundation for the corporation. The C. & G. Cooper Co. first made castings for plows, carding machines and saw mill machinery. In the late 50's the Coopers designed and built the Corliss engine for distribution in the West and they shared for many decades in the popular reception of that famous old steam plant. With the turn of the century, the Cooper company began to turn to the new natural gas and petroleum industries. In 1925 the company secured manufacturing licenses for the famous German MAN Diesel engine design. The Cooper and the Bessemer company had so paralleled their activities in 1929 that the former made a purchase of the latter and the present corporation was organized. In its hundred years, the companies have supplied some of the world's outstanding power units and particularly in the last decade when they built the biggest engines in the country for powering private yachts.

THE BABCOCK & WILCOX TUBE Co., Beaver Falls, Pa., announces the opening of a district office in Tulsa, Oklahoma, at 2002 Philtower Building, under the direction of Carl J. Hochenauer.

AMERICAN Oil Burner Assn. reports that space for its tenth annual show and convention in Hotel Stevens, Chicago, June 12-16, is approximately half taken in the first 30 da. of offering, with 5 mo. before the opening.

H. W. RINEARSON, vice-president of A. M. Byers Co., announces the promotion of M. J. Czarniecki from manager of tubular sales to general manager of sales, the change being due to departmentalization of sales activities because the company has recently broadened its wrought iron products from tubular goods to include plates, sheets, structural shapes, rivets, forging iron and welding fittings.

AT THE annual meeting of the Board of Directors of the Exhibitors Committee Industrial and Power Shows, officers elected for 1933 were: President, L. W. Shugg, General Electric Co., Schenectady; Vice-President, C. F. Radley, Oakite Products, Inc., New York City; Secretary, H. N. Shackleford, Johns-Manville Corp., New York City; Treasurer, J. P. Ferguson, Reading-Pratt & Cady, Inc., Bridgeport, Conn.; Assistant Secretary, W. A. Hemming, Exhibitors Committee, New York City. Headquarters for information on industrial and trade shows scheduled for the year are maintained at 330 W. 42nd St., New York City.

CONSOLIDATED Steel Corp., Ltd., of San Francisco, Pacific Coast representative of Forbes Wheeler Corp., has removed to larger quarters in Russ Bldg., 235 Montgomery St.

SHEPPARD T. POWELL, consulting engineer has removed his offices to 330 No. Charles St., Baltimore, Md., telephone Vernon 2071.

ROOTS-CONNERSVILLE-WILBRAHAM, report the largest volume of unfilled orders for blowers, pumps and meters since last March. Orders booked during November also exceeded total for the same month in 1931, this being the second comparative monthly gain for 1932.

THE BABCOCK & WILCOX TUBE Co. has appointed Fritz Hoving its West Coast District Sales Manager, in order to give its west coast agent, A. M. Castle & Co., the assistance of a local direct mill representative. Mr. Hoving will make his headquarters with A. M. Castle & Co. at 2200-2300 East 55th St., Los Angeles, Cal., and will maintain active touch with the offices of that company in San Francisco and Seattle.

FALK CORP., Milwaukee, Wis., announces the appointment of G. J. Sturmfelsz as representative in the Baltimore district, with offices at 1620 East 32nd Street, also the appointment of H. Douglas Stier in the Atlanta territory with offices located at 101 Marietta Street.

WORTHINGTON PUMP AND MACHINERY CORP. has announced the appointment of Hugh Benet, who has been manager of its Holyoke, Mass., works, as manager of its Harrison, N. J., works.

MANAGER'S headquarters of the plastics department of the General Electric Co. have been moved from Meriden, Conn., to Pittsfield, Mass., as announced by R. E. Coleman, manager of the department. Hot-molded products will be made at Pittsfield, cold-molded products at Meriden; sales offices are at Lynn, Mass.

FISHER GOVERNOR Co. of Marshalltown, Ia., has opened a New York City office at 30 Church St., Tel. Courtland 7-6754, in charge of O. M. Galiher, who has been for 6 yr. engineer and assistant sales manager at the factory; A. W. Bailey, for several years in charge of specialty sales in New York territory; and J. J. Belger, experienced in Fisher sales and equipment.

BERNITZ Furnace Appliance Co. has appointed McLean Peterson Co., Cincinnati, as its sales agent in southwestern Ohio and Reese-Wilson Engineering Sales Co., Cleveland for northeastern Ohio.

ELMER E. GILBERT, sales manager of the turbine department of the General Electric Co., retired January 1 after 43½ yr. of service with the company and the Thomson-Houston Electric Co., one of its predecessors. His career with General Electric completely spanned the period during which the steam turbine has been developed into one of the dominant factors in the economic progress of the nation.

R. B. Beales, formerly assistant manager, is now managing the turbine sales department which has been made a division of the central station department.

Power Plant Construction News

Ariz., Kingman—Desert Power & Water Co., Kingman, plans rebuilding of portion of power plant and water station, recently destroyed by fire with loss of about $50,000, including equipment.

Ariz., Tucson—Oliver M. Preston, 1603 East Sixth Street, and associates are organizing company to construct and operate a brewing plant on South Twenty-fifth Street, to include power house, refrigerating plant, pumping station and other mechanical units. Plans will soon be drawn. Entire project is reported to cost over $200,000.

Conn., Hartford—Connecticut Electric Service Co., Hartford, is arranging an appropriation of $2,047,738, for extensions and betterments in plants, power substations, transmission and distributing lines in 1933. Company engineering department will be in charge.

Del., Wilmington—Delaware Electric Power Co. is arranging a fund of $138,171 for extensions and improvements in electric stations and system during 1933, and about $286,100 for similar work at artificial gas plants, including additions to distributing lines. Company engineering department will be in charge.

Ga., Brunswick—Georgia Power Co., Atlanta, Ga., is planning extensions and improvements in steam-operated electric power plant at Brunswick, to double present capacity. Extensions will also be made in transmission lines. Program is reported to cost over $100,000. Company engineering department is in charge.

Ga., Valdosta—City Council plans installation of a new pumping plant, elevated steel tank and tower with capacity of 300,000 gal., pipe lines and other equipment in connection with extensions and improvements in municipal waterworks. Entire project is reported to cost about $100,000. Robert & Co., Bona Allen Building, Atlanta, Ga., are engineers.

Ind., Hammond—Shell Petroleum Corporation, Shell Building, St. Louis, Mo., plans installation of electric power equipment, tanks and other mechanical equipment in connection with an expansion and improvement program at oil refining plant at Hammond, entire project to cost about $600,000. Company engineering department is in charge.

Iowa, Hamburg—Common Council, Ralph Travis, city clerk, is considering construction of a municipal electric light and power plant. Estimated cost $150,000, with equipment. Proposed to hold special election to approve bond issue in amount noted at early date.

Iowa, Logan—Common Council is said to be considering the construction of a municipal electric light and power plant. Station is estimated to cost about $100,000, and it is proposed to hold special election at early date to vote bond issue in that amount. Plans will soon be drawn for station.

Ky., Lexington—Citizens Ice Co., Lee Congleton, 54 Mentelle Park, head, recently organized by Mr. Congleton and associates, has acquired property at 120 York Street as site for new ice-manufacturing plant, for which plans will soon be drawn. Plant will have capacity of about 20 t. per day and is estimated to cost about $25,000, with equipment.

Md., Baltimore—Mexican Petroleum Corporation, 122 East Forty-second Street, New York, N. Y., an interest of Pan-American Petroleum & Transport Co., same address, plans installation of steam power equipment, pumping plants, pipe lines, tanks and other mechanical equipment in new addition to oil refining plant in East Brooklyn district. Project will cost over $1,000,000. Company engineering department is in charge.

Mich., Grand Rapids—Department of Public Works, City Hall, is considering construction of a steam-electric power plant near Coldbrook Street, for municipal works service. Unit is estimated to cost about $70,000, with equipment.

Minn., Tracy—Liquefied Natural Gas Corporation, Foshay Tower Building, Minneapolis, Minn., has plans under way for a natural gas distributing plant at Tracy, for service at that place and nearby communities. Installation will include compressors, tanks, pipe lines, etc., and is reported to cost about $40,000. Work will begin in the spring. H. H. Henley is company engineer.

Mo., Kansas City—Gasconade River Power Co., 605 R. A. Long Building, Kansas City, is said to have plans maturing for new hydroelectric generating plant on Gasconade River, Phelps County, for which a preliminary Federal permit recently was secured. Work will include power dam 130 ft. high and about 1800 ft. long, with power plant of 60,000 hp. capacity, divided into four 15,000 hp. generating units. Entire project will cost over $10,000,000, with transmission system.

N. J., Atlantic City—Atlantic City Brewing & Ice Co., 105 North Missouri Avenue, recently organized to take over Atlantic City Ice Co., plans installation of electric power equipment, tanks, conveyors and other mechanical equipment in connection with extensions and improvements in brewing plant. Cost over $200,000. Charles Proebstle is president.

N. M., Hot Springs—Common Council is said to be considering construction of a municipal electric light and power plant, and will have estimates of cost and surveys made in near future.

N. Y., Brooklyn—City Brewing Corporation, 91 Cypress Avenue, plans installation of electric power equipment, tanks, refrigerating machinery and other mechanical equipment in connection with an expansion and modernization program at brewing plant. Estimated cost about $275,000. John Koenig is president; Frederick Paulsen is secretary and company engineer.

N. Y., New York—Standard Gas & Electric Co., 111 Broadway, operating electric light and power properties in Kentucky, Oklahoma, Wisconsin, Minnesota, California, and other States, has authorized a fund of $12,474,753. for extensions and improvements in power plants, substations, transmission and distributing lines, and miscellaneous structures in 1933.

N. C., Lexington—C. M. Wall & Son Co., Lexington, plan installation of electric power equipment in connection with proposed rebuilding of wooden box and shook manufacturing plant, recently destroyed by fire. Loss over $100,000.

N. D., Grand Forks—Committee has been appointed by Mayor J. L. Hulteng to arrange for surveys and estimates of cost for a proposed municipal electric light and power plant. Entire project to cost over $500,000.

Ohio, Akron—Furnas Ice Cream Co., 34-42 North Broadway, plans installation of electric power equipment, refrigerating machinery, tanks and other mechanical equipment in new ice cream-manufacturing plant. Project will cost over $75,000. Roland C. Davenport is manager.

Pa., Erie—Erie County Electric Co., Erie, is arranging appropriation of $131,147, for extensions and improvements in power plants and system in 1933. Company engineering department in charge.

Pa., Philadelphia—Philadelphia Electric Co., Tenth and Chestnut Streets, has taken out a permit for addition to steam-operated electric generating plant at Delaware Avenue and Lewis Street, estimated to cost $500,000, with equipment. Company is arranging a fund of $9,218,000 for extensions and improvements in power plants and system during 1933. United Engineers & Constructors, Inc., 1401 Arch Street, is engineer for power station addition noted.

Pa., Philadelphia—Philadelphia Gas Works Co., 1401 Arch Street, is planning an expansion and reconstruction program to be carried out over a period of months, including installation of new turbine-driven gas pump and accessories at Station A, with capacity of 1,000,000 cu. ft. gas per hour, gas engine-driven air compressors in several plants and other operating equipment, as well as 30-in. dia. and smaller steel pipe lines, etc. Work will cost over $500,000. Company engineering department will be in charge.

S. C., Abbeville—Abbeville Power Co., recently organized by J. Roy Pennell, 134 Pine Street, Spartanburg, S. C., and associates, has plans under way for a hydroelectric power development on Rocky River, vicinity of Abbeville, with power dam about 60 ft. high and 570 ft. long. Entire project will cost over $175,000, with transmission lines. Mees & Mees, Court Arcade, Charlotte, N. C., are engineers.

Texas, Smithville—Common Council is said to be considering installation of a municipal electric light and power plant, and will have estimates of cost made at early date. H. F. Polansky, mayor, is at head of project.

W. Va., Huntington—Pure Ice Co., 524 Twentieth Street, plans construction of a one-story ice-manufacturing plant at Seventh Avenue and Second Street, to be equipped for a capacity of about 75 tons per day. Estimated cost about $65 000, with machinery. H. E. Crowder is general manager.

Wis., Milwaukee—Milwaukee Gas Light Co., Milwaukee, is planning fund of about $225.000, exclusive of labor, for extensions and improvements in artificial gas plants and system during 1933. Company engineering department will be in charge.